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Vol. XXVI No. 9 Whole No. 227

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SCHOOL SCIENCE AND MATHEMATICS

A Journal for all Science and Mathematics Teachers

Founded by C. E Lineberger

TURTON & WARNER, Publishers

Publication Office, 404 N. Wesley Ave., Mount Morris, Illinois

CHICAGO OFFICE, 2055 East 72nd Place, CHICAGO, ILL.

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Published monthly, October to June, Inclusive, at Mount Morris, Illinois
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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXVI, No. 9. DECEMBER, 1926 WHOLE No. 227

THE MECHANICAL PROCESSES IN INTRODUCTORY CALCULUS AND ANALYTICAL GEOMETRY.

BY BLANDENA C. COUILLARD,

University of Maine, Orono, Maine.

"A mechanical process is one which should be done more through habit obtained by sufficient practice than through a train of reasoning. An example of this would be simple factoring." [Definition given by Prof. Bryan of University of Maine.]

This report consists of a series of discussions, questions and answers which cover rather fully an eighteen week course in the fundamentals of introductory calculus and analytical geometry. When these tests were first given the text book used by the class was "An Introduction to Calculus" by Longley and Wilson. These tests, however, are not those which would pertain distinctly to this text book but could be used to test the mechanical processes of the subjects as they might appear in any up-to-date text book. As is shown by the definition of the mechanical processes these tests are solely for the purpose of testing the fundamental facts of a like course.

In this course a brief space is at first devoted to the necessary prerequisites in analytical geometry before studying the calculus.

In the different chapters there are different numbers of questions in the sets, but practically all sets have either twenty or twenty-five questions. The scope is so much greater in some subjects than in others that it is impossible to limit the number of questions.

In all these tests the greatest possible heed was taken not to repeat a question which tested an identical principle that had been tested before. Each example has some small difference which makes it stand out as a separate process.

Some of the objects of testing the mechanical processes are:

(1) To measure the standing and progress of pupils from time to time.

(2) To classify members of the class according to ability.

(3) To study the difficulties of the class as a whole and also of the individual pupils.

(4) To determine the degree of mastery of the subject.

(5) To act as an incentive to the pupil: (a) To a complete mastery of the essential facts and processes. (b) To a systematic organization of the field covered by the test.

The different subjects which were studied and tested are as follows:

I. Cartesian Coördinates. The Straight Line.

II. Equations of Curves.

III. Slope and Derivative.

IV. Differentation of Algebraic Functions.

V. Maximum and Minimum Values.

VI. Indefinite Integrals, Constant of Integration, Definite Integrals.

For each of these subjects there is to be a brief discussion, a copy of the test and the answers.

1. Cartesian Coordinates—The Straight Line.

This is the first subject to be studied in a beginners course for it lays the foundation upon which so much of the following work depends. The first step in this new combination of algebra and geometry is the description of the position of a point. From this is developed the ideas of straight lines and angles.

Test.

(1) Plot the points: (4, 3), (4, −3), (−3, 4), (0, 10).
(2) Three vertices of a square are: A (2, 0), B (8, 0), C (2, 6). What are the coordinates of the 4th vertex?
(3) What are the coordinates of a point which is symmetrical to (2, 2) with respect to the origin?
(4) What is the abscissa of a point (3, 5)?
(5) What is the ordinate of a point (6, 3)?
(6) Draw the triangle having the following points as vertices: (−2, 0), (6, 0), (4, 8).
(7) What is the distance between (4, 6) and (1, 2)?
(8) Given $2x-y = 2$. Find the slope.
(9) Write the equation of the system of lines having slope 2.
(10) If the middle point of a line is (6, 2) and one end of the line is (10, −4) what are the coordinates of the other end?
(11) Determine k so that $x-ky+3 = 0$ passes through (3, 1).
(12) Find the equation of a line through the point (1, 5) which has a slope of $\frac{1}{2}$.
(13) Find the equation of a line passing through the points (4, 2), (3, 1).
(14) What is the equation of the line $\parallel$ to $x-2y+1 = 0$ passing through (1, 2)?
(15) What is the equation of the line perpendicular to $2x-3y+5 = 0$ passing through the origin?
(16) Find the points of intersection of lines $x+3y+5 = 0$ $x-y+1 = 0$

(17) What is the equation of the line with the x intercept equal to 2 and the y intercept equal to 3?
(18) Two lines are perpendicular in respect to one another. The slope of one is -1. What is the slope of the other?
(19) Two lines are parallel in respect to one another. The slope of one is $\frac{1}{2}$. What is the slope of the other?
(20) Write the equation of a system of lines passing through $(-2, 3)$.
(21) What are the intercepts of a line whose equation is $x-y-2 = 0$?
(22) What is the slope of a line whose inclination is 45°?
(23) Find the slope of the lines joining (4, 1) (2, 2).
(24) What is the locus of the equation $ax+by+c = 0$?
(25) Draw several lines of the system $x-2y+k = 0$.

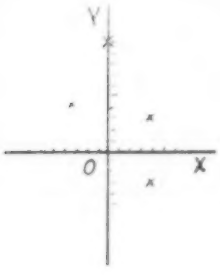
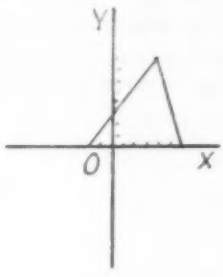


FIG 1



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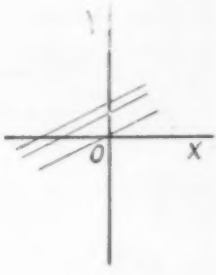


FIG 3

Answers.

1. See Fig. 1.
2. (8, 6)
3. $(-2, -2)$
4. 3
5. 3
6. See Fig. 2.
7. 5
8. 2
9. $y = 2x+b$
10. (2, 8)
11. $k = 6$
12. $x-2y+9 = 0$
13. $x-y-2 = 0$
14. $x-2y+3 = 0$
15. $2y+3x = 0$
16. $(-2, -1)$
17. $3x+2y-6 = 0$.
18. 1
19. $\frac{1}{2}$
20. $y-3 = m(x+2)$
21. $x = 2 \quad y = -2$
22. 1
23. $-\frac{1}{2}$
24. Straight Line
25. See Fig. 3.

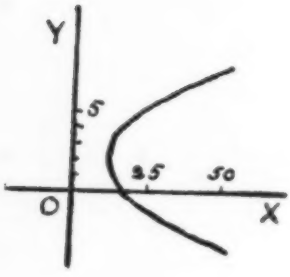
2. Equations of Curves.

From the straight line the equation of which is of the first degree, we now advance to the equations of curves. In general it will be found that to every equation not of the first degree there corresponds a curve and that every curve has a definite equation. In the work of this chapter special attention is paid to plotting graphs and equations.

Test.

1. Does the graph $x^2+4xy+y^2-4x-3y+12 = 0$ pass through the origin? Why?
2. Plot the graph of $5y^2-10y = x-15$.
3. Plot the graph of $4x^2+y^2 = 20$.
4. Plot the graph of $xy = -4$.
5. Plot the graph of $y = x^3-2x^2$ for the range of values $x = -3$ to $x = 3$.
6. Investigate the intercepts and symmetry of the graph of $y = x^3-x$.
7. Given $y = 8-x^2$ what is the largest value of y?

8. For what value of p will the graph of $y = 2px$ pass through the point (16, 4)?
9. Plot by factoring the loci of $y^2+5y-6 = 0$.
10. Find the equation of the locus of a point equidistant from (3, 2) and (6, −2).
11. Find the equation of the circle, the center (9, 0) and the radius 9.
12. Find the equation of the locus of a point equidistant from the line $y = 6$ and the point (3, 0).
13. Find the locus of a point if its distance from the point (−4, 0) is always twice its distance from the point (2, 0).
14. Find the equation of the locus of a point equidistant from the line $x = 0$ and the point (p, 0).
15. Find the equation of the circle having radius r and center (h, k).
16. Find the points of intersection of the curves $x^2+y^2=16$ and $y^2 = 6x$.
17. Find the points of intersection of the curves $y = \frac{8}{4+x^2}$ and $x^2 = 4y$.
18. Plot the system of curves whose equation is $x^2+y^2 = r^2$.
19. Plot on the same axes 3 curves of the system whose equation is $y^2 = kx$.
20. Plot the graph of $x = -3$.



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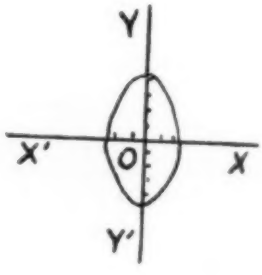

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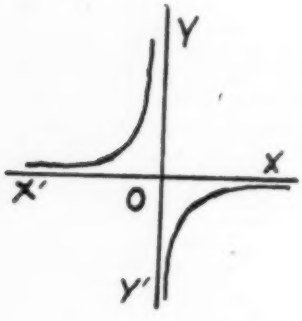

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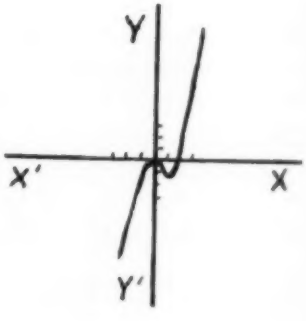

FIG 7

Answers.

1. Substitute. If $x = 0$ and $y = 0$ then $12 = 0$ which is false. Hence the graph does not pass through the origin.
2. See Fig. 4.
3. See Fig. 5.
4. See Fig. 6.
5. See Fig. 7.
6. Curve is symmetrical with respect to the origin
7. $y = 8$
8. $p = 1/8$
9. See Fig. 8.
10. $6x - 8y = 27$
11. $x^2 - 18x + y^2 = 0$
12. $x^2 - 6x + 12y = 27$
13. $x^2 + y^2 - 8x = 0$
14. $y^2 = 2px - p^2$
14. $(x-h)^2 + (y-k)^2 = r^2$
16. $(2, \sqrt{12})$ $(2, -\sqrt{12})$
17. $(2, 1)$ $(-2, 1)$
18. See Fig. 9.
19. See Fig. 10.
20. See Fig. 11.

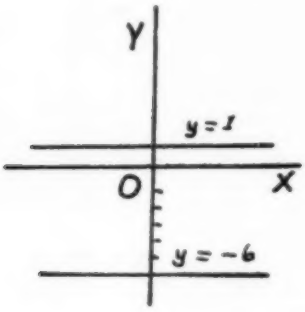

FIG 8

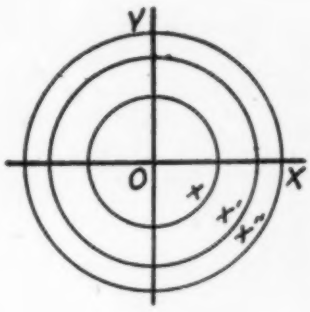

FIG 9

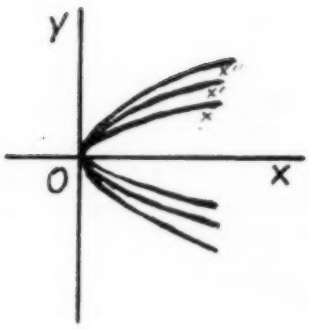

FIG 10

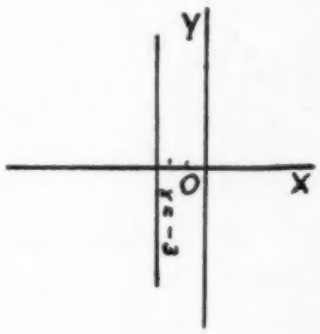

FIG 11

III. Slope and Derivative.

The work in this topic deals with the necessary prerequisites for the undertaking of differentiation by formulas. It gives an

idea of the development and scope of the subject. This method of finding a derivative is applicable in theory to any function, but in practice this involves too great labor to be efficient.

Test.

1. If $f(x) = x^3-3x^2+4x+1$, what does $f(2)$ equal?
2. If $f(x) = x^3-3x^2+4x+1$, what does $f(t)$ equal?
3. Write the equation $x^2+2y^2 = 4$ in the form $y = f(x)$.
4. Write the equation $x^2+2y^2 = 4$ in the form $x = g(y)$.
5. If $y = x^2-6x$, compute increment y, when $x = 2$ and increment $x = 0.3$.
6. For $y = x^3$, find increment y in terms of x and increment x.

Find the slope of:

7. The tangent to the curve $y = x^2$ at $(-2, 4)$.
8. The secant line for the curve $y = x^2$ when increment $x = 0.5$.
9. The curve $y = x^3$ at $x = 0$.
10. The curve $y = 5x-x^2$ at any point (x, y).
11. The curve $y = x^2-3x$ at $x = 0.3$.
12. The curve $y = x^2$ at all the points whose abscissas are 1, 2, 3, 10.

By use of the fundamental rule find the derivatives of the following:

13. $y = 3x^2$
14. $y = 8/x$
15. $y = 2-x^2$
16. $s = 3t^2$
17. $s = c/t$
18. $s = at^2$
19. $f(t) = 2/t$
20. By setting the derivative equal to zero, find the points at which $4y = 12x-x^2$ is parallel to the $x-$ axis.

Answers.

1. $5 = f(2)$
2. $t^3-3t^2+4t+1 = f(t)$
3. $y = \dfrac{\sqrt{4-x^2}}{\sqrt{2}}$
4. $x = \sqrt{4-2y^2}$
5. $0.51 = -0.51$
6. $3x^2\triangle x+3x(\triangle x)^2+(\triangle x)^3$
7. $m = -4$
8. (-3.5)
9. $m = 0$
10. $m = 5-2x$
11. $m = (-3,3)$
12. $m = 2, 4, 6, 20$
13. $dy/dx = 6x$
14. $dy/dx = -8/x^2$
15. $dy/dx = -2x$
16. $ds/dt = 6t$
17. $ds/dt = -c/t^2$
18. $s' = 2$ at
19. $f'(t) = -2/t^2$
20. $x = 6 \quad y = 9$

IV. Differentiations of Algebraic Functions.

This topic deals primarily with the finding of derivatives by certain set formulas. The derivation of such formulas is shown and much practice is given in handling them. The formulas given in this chapter for differentiation are as follows:

1. $d/dx\, x^n = n\, x^{(n-1)}$
2. $d/dxc = 0$
3. $d/dx(x) = 1$
4. $d/dx(u+v) = du/dx+dv/dx$
5. $d/dx(u\,v) = u\, dv/dx+v\, du/dx$
6. $d/dx(c\,v) = c\, dv/dx$
7. $d/dx\left(\dfrac{u}{v}\right) = \dfrac{v\, du/dx-u\, dv/dx}{v^2}$
8. $dy/dx = dy/du \cdot du/dx$
9. $d/dx(u^n) = nu^{n-1}\, du/dx$
10. $dy/dx = 1/dx/dy$

Test.

Find dy/dx

1. $y = 5x^2-8x+2$
2. $y = \sqrt{x}$
3. $y = 3x^{-2}-2x^{-3}$
4. $y = 1/x+1/x^2$
5. $y = x^2/4-3x$ when $x = 4$
6. $xy = 18$

By product formula, exs. 7–9 find dy/dx

7. $y = (2x-1)(x+2)$
8. $y = x^2(x+1)$
9. $y = (2x-1)(x+1)(3x+2)$

By quotient formula, exs. 10–11 find dy/dx

10. $y = \dfrac{x-3}{x+2}$
11. $xy = x+1$ when $x = 2$

Find dy/dx

12. $y = u^8$ $u = 2+\sqrt{x}$
13. $y = \sqrt{2+3x}$
14. $y = (4-2x)^3$
15. $y = x^2+4/x$ when $x = 2$
16. Find dx/dy $y = 1x^2-2$
17. Find ds/dt $s = t^2-\sqrt{t}$
18. Solve implicitly $x^2+xy+y^2 = 0$
19. Find second derivative $y = 4x^5-3x^3+10x-1$
20. Find third derivative $y = 7x^3+10^2+3x+1$

Answers.

1. $dy/dx = 10x-3$
2. $dy/dx = 1/2\sqrt{x}$
3. $dy/dx = -6/x^3+6/x^4$
4. $dy/dx = -1/x^2-2/x^3$
5. $dy/dx = -1$
6. $dy/dx = -18/x^2$
7. $dy/dx = 4x+3$
8. $dy/dx = 3x^2+2x$
9. $dy/dx = 18x^2+14x-1$
10. $dy/dx = 5/(x+2)^2$
11. $dy/dx = -1/x^2,\ -1/4$
12. $dy/dx = \dfrac{7(2+\sqrt{x})^7}{2\sqrt{x}}$
13. $dy/dx = 3/2(2+3x)^{-\frac{1}{2}}$ or $\dfrac{3}{2\sqrt{2+3x}}$
14. $dy/dx = -6(4-2x)^2$
15. $dy/dx = 3$
16. $dy/dx = \dfrac{1}{2\sqrt{y}+2}$
17. $ds/dt = 2t-\dfrac{1}{2\sqrt{t}}$
18. $dy/dx = \dfrac{2x+y}{x+2y}$
19. $dy/dx = 80x^3-18x$
20. $dy/dx = 42$

V. Maximum and Minimum Values.

The work of the first four chapters has been mainly geometrical but now comes the applications of these subjects in a way which is not primarily geometrical. It is now possible by the previous study of differentiation to find the maximum and minimum values of equations.

Test.

1. Express the area of a square as a function of its diagonal.
2. In a class numbering 50, the grades were distributed as follows:

Grade	95	90	85	80	75	70	65	60	55	50
Number	1	2	6	9	5	10	6	4	4	3

Exhibit this graphically.

3. Is $y = x/(1+x^2)$ increasing or decreasing for $x = 0$ and $x = 2$?
4. For what values of x is the following function increasing: $y = 3x - x^3$?
5. In the following equation, determine the values of the independent variable for which the function is increasing and those for which it is decreasing.

$$x^3 - 2x^2 - 5x + 6 = 0.$$

6. Examine $y = x^2 - 5x + 3$ for maximum and minimum values.
7. Draw the graph for number 6.
8. Examine $y = 2x^3 - 3x^2 + 6x - 2$ for maximum and minimum values.
9. Find two numbers whose sum is 20 such that the sum of their square is a minimum. (Method must show truth of result.)
10. A piece of wire of length 20 inches is bent into a rectangle, one side of which is x. Find the value of x that will give a maximum area.

Answers.

1. $d^2/2$
2. See Fig. 12.
3. Increasing for 0. Decreasing for 2.
4. Increasing for all values of x between -1 and $+1$.
5. Increasing when $x < 2$. Decreasing when $x > 3\ 1/8$.
6. Minimum $(5/2, -13/4)$.
7. See Fig. 13.
8. No maximum or minimum. Increasing steadily.
9. (10, 10)
10. $x = 5$.

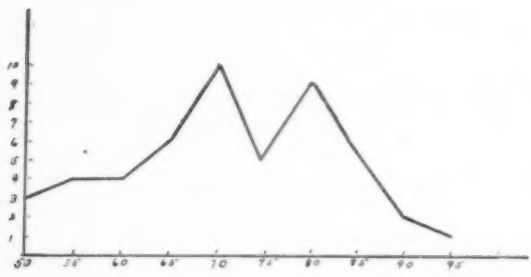

FIG 12

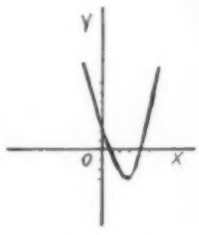

FIG 13

VI. Indefinite Integrals. Constant of Integration. Definite Integrals.

After a brief study of differentiation the next step forward to be taken is the study of integration. As in differentiation there are certain formulas of importance which appear at this stage of the work. They are as follows:

1. $\int du = u + c$
2. $\int [f(x) + g(x)]\, dx = \int f(x)\, dx + \int g(x)\, dx$
3. $\int a\, du = a \int du$

$$4.\ \int u^n\,du = \frac{u^n+1}{n+1} + c \text{ if } n \neq -1$$

In this type the pupils get a clear idea of simple indefinite integrals, constant of integration, and definite integrals. There is much practice in using formulas in all these.

Test.

Integrate:

1. $70\,x^5dx$
2. $(6x^4+5x^3+4x^2-3x+2)dx$
3. $(6/x^6)dx$
4. $(6x)^{\frac{1}{2}}\,dx$
5. $(6x^2+4x+6/x^2)dx$
6. $(x-5)^{\frac{1}{2}}\,dx$
7. $xdx/(25-x^2)^{\frac{1}{2}}$
8. $(3x/x^{\frac{1}{2}})dx$
9. $(3x-2)^3dx$

Integrate by substitution:

10. $xdx/(3+x)^{\frac{1}{2}}$
11. $x(5-x)^{\frac{1}{2}}\,dx$
12. $(a+bx)^{\frac{1}{2}}\,dx$

In problems (13. 14) find the function whose differential is given and which satisfies the given initial conditions.

13. $ds = (t^2-2t^{\frac{1}{2}})dt$; $s = 7$ when $t = 0$.
14. $dy = \dfrac{6-x^3}{x^4}\,dx$; $y = 2$ when $x = 1$. Find value of y when $x = -1$.

In problems (15, 16) find the equations of the curve which has the given slope at every point and which passes through the given point.

15. $dy/dx = (xy)^{\frac{1}{2}}$ (1, 1)
16. $dy/dx = x/(x^2+4)^{\frac{1}{2}}$; (0, 2)
17. Find the system of curves defined by $dy/dx = 3x/y$.

Find the value of the following between the limits stated:

18. $x^{1/3}dx$; $x = 1$ and $x = 8$.
19. $dt/(4-t)^{\frac{1}{2}}$; $x = 0$ and $x = 3$.
20. $xdx/(2x+5)^{\frac{1}{2}}$; $x = -2$ and $x = 2$.
21. Find the area bounded by the curve $y = \dfrac{x^3}{3}$ and the lines $x = 0$ and $x = 4$.
22. Find the area bounded by the curve $x+y = 10$, and the $y-$axis and the lines $y = 2$ and $y = 3$.
23. Find the area bounded by $y = 4-x^2$ and the $x-$axis.
24. Find the area bounded by the parabola $y^2 = 4x$ and the line $y = x$.
25. Evaluate the definite integral of $x(a-x)^{\frac{1}{2}}\,dx$ between the limits $x = 0$ and $x = a$.

Answers.

1. $70x^{\frac{1}{2}}/6+c$
2. $6/5\ x^5+5/4\ x^4+4/3\ x^3+3/2\ x^2+2x+c$
3. $-6/5\ x^{-5}+c$
4. $2/3\ x\sqrt{6x}+c$
5. $2\ x^3+2x^2-6x^{-1}+c$
6. $2/3\ (x-5)\ 3/2+c$
7. $-(25-x^2)^{\frac{1}{2}}+c$
8. $2x^{3/2}+c$
9. $1/12\ (3x-2)^4+c$
10. $2/3\ (3+x)^{3/2}-6\ (3+x)^{\frac{1}{2}}+c$
11. $2/5\ (5-x)^{5/2}-10/3\ (5-x)^{3/2}+c$
12. $2/3b\ (a+bx)^{3/2}+c$
13. $s = 1/3\ t^3-4/3\ t^{3/2}+7$
14. $y = 4$
15. $3\sqrt{y} = x^{3/2}+2$
16. $y = (x^2+4)^{\frac{1}{2}}$
17. $y^2-3x^2 = c$
18. 11 1/4
19. 2
20. $-2/3$
21. 64/3
22. 15/2
23. 16/3
24. 8/3
25. $4a^{3/2}/15$

In concluding this report there is to be a tabulation showing:

1. The number of examples done by each individual in each set.
2. The percentage of each individual in each set.
3. An average percentage of all tests for each individual.

These percentages do not represent grades, but are for the purpose of comparison.

	I		II		III		IV		V		VI		Av.
	No. Right	%	No. Right	%	No. Right	%	No. Right	%	No. Right	%	No. Right	%	%
1	13	52	10	50	19	59	18	90	7	70	19	76	72
2	12	48	7	35	19	95	16	80	.....	.....	14	56	63
3	20	80	17	81	19	95	20	100	9	90	24	96	90
4	7	24	7	35	16	80	14	70	5	50	3	12	45
5	.....	.....	7	35	12	60	13	65	4	40	8	34	46
6	13	52	6	30	16	80	9	45	4	40	9	36	47
7	11	45	6	30	20	100	14	70	4	40	9	36	54
8	11	45	8	40	16	80	14	70	5	50	11	45	55
9	6	24	8	40	14	70	10	50	3	30	8	32	41
10	12	48	11	51	16	81	12	60	3	30	17	68	56
11	10	40	12	60	19	95	.....	.....	5	50	15	60	51
12	9	36	8	40	18	90	12	60	5	50	14	56	55
13	.....	.....	13	61	18	90	18	90	8	80	15	60	76
14	12	48	9	41	14	70	15	75	3	30	9	36	50
15	11	45	12	60	18	90	.....	.....	6	60	13	52	61
16	.....	.....	14	70	18	90	.....	.....	7	70	18	72	75
17	9	36	12	60	15	75	19	95	4	40	13	52	60
18	.....	.....	5	25	19	95	18	90	3	30	12	48	58
19	17	68	11	51	19	95	17	85	8	80	14	56	73
20	8	32	14	70	19	95	11	55	3	30	8	32	50
21	15	60	14	70	18	90	20	100	9	90	14	56	78
22	9	36	14	70	17	85	19	95	7	70	17	68	71
23	16	64	13	61	15	75	15	75	7	70	9	36	64

JUPITER CHANGES ASPECT.

Remarkable changes on the surface of Jupiter, as seen through the telescope, have occurred since June 1, declares E. C. Slipher, of the Lowell Observatory, prominent planetary observer. These have taken place principally in the planet's southern hemisphere, almost all of which has been affected, chiefly the broad belts which normally surround the planet, parallel to the equator, something like the zones on a terrestrial globe.

"The south tropical belt, which was broad and prominent in 1925 and earlier, has almost disappeared during the last two motnhs," says Mr. Slipher, "and now that part of the planet is covered by a broad bright belt which is slightly brighter than the equatorial bright belt."

Another change has affected the "Great Red Spot." This first appeared in 1878 when it was about 25,000 miles long and 8,700 miles wide. At first it had a distinct reddish color, but this later faded out. According to Mr. Slipher, it now appears to show considerable color again, being decidedly pink, instead of the neutral gray that it has been in recent years.

"It is of interest to note," he says, "that in 1919 a change swept over the same region of Jupiter producing sensibly the same changes that have occurred in the present disturbance, and later the dark belts reappeared in much the same form and position that they formerly possessed." Jupiter can now be seen as a brilliant star in the southern evening sky. —*Science Service.*

A PRELIMINARY REPORT ON THE PROGRESS AND ENCOURAGEMENT OF SCIENCE INSTRUCTION IN AMERICAN COLLEGES AND UNIVERSITIES, 1912-22.*

By N. M. Grier,
Des Moines University.

(Concluded)

Table I. Gain or Loss in Science Registration by Departments.

Subject	No. Instit.	No. In. showing increase	No. In. showing decrease	No. showing neither	W. Coll. showing increase	W. Coll. showing decrease	W. Coll. showing no gain	Instit. gaining in order from greatest to least gain	Instit. losing in order from greatest to least loss
All Biology	35	16	18	1	5	5	0	S. N.E.M.C.I. N.	N.E.W.C.
All Chemistry	37	22	15	0	8	3	0	W. N.E.M.C.I. N.E.W.C. S.	N.
All Physics	35	16	17	2	8	2	2	S. N.E.W.C.	W. N. N.E.M.C.I
All Geology	23	9	13	1	4	3	0	N.E.W.C. W.	N.E.M.C.I. N. S.
Astronomy	21	7	10	4	3	2	3	W. N.E.W.C.	N.E.M.C.I. S. N.

IV. Conclusions.

The preceding observations are conveniently summarized in Tables I and II. The conclusions now given must be considered as being limited by the amount of data the writer has been able to secure.

1. The following sciences have been declining in enrollment at the majority of institutions studied, viz.: Astronomy, biological sciences (including those of botany, zoology and physiology and hygiene), geological sciences (including physical and historical geology and physics). The question as to whether the loss of enrollment in these sciences at certain institutions is compensated for by the gain at others is best answered by the reader's study of the accompanying graphs.

2. The following sciences have increased in enrollment at the majority of institutions studied, viz., chemical sciences

*Graphs drawn by Mr. Kenneth Simonds, Dartmouth, '26.

TABLE II. GAIN OR LOSS IN SCIENCE REGISTRATION BY SUBJECT.

Subject	No. Institutions	No. In. showing increase	No. In. showing decrease	No. showing neither	W. Coll. showing increase	W. Coll. showing decrease	W. Coll. showing no gain	Instit. gaining in order from greatest to least gain	Instit. losing in order from greatest to least loss
Zoology (all branches)	24	9	12	3	4	2	1	N. S.	W. N.E.M.C.I. N.E.W.C.
Botany (all branches)	25	10	15	0	2	4	0	S.	N.E.M.C.I. W. N. N.E.W.C.
Physiol. and Hygiene	18	7	10	0	4	4	0	W. S. N.E.W.C.	N. N.E.M.C.I.
Gen. Biology	17	9	7	1	3	2	0	N.E.M.C. S. W. N.E.W.C.	N.
Gen. Chem.	22	12	10	0	5	2	0	N.E.W.C. W. M.E.M.C.I.	N. S.
Gen. Physics	21	13	7	1	5	1	0	S. N.E.W.C. N.	N.E.M.C. W.
P. and H. Geology	13	4	9	0	1	4	0	W. N.E.W.C.	N. N.E.M.C.I.[11]

[11]Southern institutions show no change.

(including general chemistry) general physics, general biology. The question as to whether the gain in enrollment in these sciences at certain institutions is balanced by the loss at others is best answered by the reader's study of the accompanying graphs.

3. It apparently follows from the preceding that the first year of biological, chemical and physical science is becoming increasingly popular with students, but for some reason within or without their control, these departments fail to hold students for advanced work in them. Possible reasons for this situation are cited in connection with the discussion of each subject. Judged by the proportion of increase and decrease in enrollment, the subjects in regard to popularity with students rank in the following order: general physics, general biology, general chemistry.

4. The decline in enrollment discussed in the first paragraph apparently parallels the situation in the secondary schools in the cases of the sciences of astronomy, geology (physiography), botany, zoology, and physiology.

5. The increase in enrollment at the majority of instutions in the collegiate sciences of general biology, general physics and general chemistry is apparently paralleled by the increases in the corresponding courses in the secondary school.

6. It must be the regret of all interested in the study of the enrollment statistics of colleges and universities that these in many cases are neither complete nor accessible; that the lack of a commonly accepted procedure in keeping them makes unusually difficult, studies of value to the college administrator and the teachers themselves. This also seems to be the most convenient place to point out that the same criticisms may be directed in part toward the methods of keeping the financial statistics, although it is understood that there has been some attempt to standardize the procedure in this regard among college accountants. Of interest in connection is that followed at the University of Washington. Colleges and universities might profitably copy some of the methods used for preserving and interpreting such data in the larger school systems. There is a need for text-books dealing with the administration of these phases of higher education.

7. The proportion of the total registration represented by that of the subjects dealt with in this paper is given in the following table.

TABLE III. PERCENTAGE OF ENROLLMENT IN 1922.

Subject	No. Institutions	Min.	Mean	Max.
All Biology	35	3%	31.6%	81%
Zoology	22	1%	10%	33%
Botany	27	1%	8%	33%
Physiology	18	1%	9%	28%
Gen. Biology	17	1%	15%	36%
All Chemistry	36	8%	30%	70%
Gen. Chemistry	22	5%	19%	41%
All Physics	33	1%	16.8%	39%
Gen. Physics	19	2%	13%	32%
All Geology	27	2%	11%	43%
Geology	14	2%	6%	23%
Astronomy	20	1%	4.3%	16%

V. SUGGESTIONS AS TO CAUSES OF FACTS.

These have been taken up in the order of the heading of each

TABLE IV

APPROPRIATIONS – SUPPLIES AND EQUIPMENT ONLY

	Average Annual Appropriation Biology 1912–1922	Average Number Students Yearly	Average Annual Expenditure Per Student	Average Annual Appropriation Physics 1912–1922	Average Number Students Yearly	Average Annual Expenditure Per Student	Average Annual Appropriation Chemistry 1912–1922	Average Number Students Yearly	Average Annual Expenditure Per Student	Average Annual Appropriation Geology 1912–1922	Average Number Students Yearly	Average Annual Expenditure Per Student	Average Annual Appropriation Astronomy 1912–22	Average Number Students Yearly	Average Annual Expenditure Per Student
NEWC	$1593.50	862.4	$1.84	$1051.55	311.2	$3.05	$3759	464.3	$8.09	*	*	*	*	*	*
NEWC	$2023.50	576.4	$3.52	$631.10	231.1	$2.73	$3153.90	409.2	$7.70	$47.30	91.5	$.51	$243.66	98.2	$2.48
(1) NEWC	$5863.83	514.6	$11.39	$2237.66	136.5	$16.88	$1294.33	240.33	$5.38	$832.83	120.5	$6.91	$350.3	82.8	$4.23
(2) NEWC	$1383.52	169.8	$8.15	$529.05	31	$17.06	$1751.99	75	$23.36	*	*	*	*	*	*
(3) NEWC	$1650	142	$11.60	$1250	26	$48.07	$1350	58	$23.27	*	*	*	*	*	*
(4) NWC	$1184.29	75	$15.79	$1461.26	44.6	$32.77	$1601.14	48.1	$33.28	$734.78	27.1	$27.11	*	*	*
(5) SWC	$409.71	77.2	$5.30	$785.31	34.2	$22.96	$863	28.8	$29.96	*	*	*	*	*	*
NEMCC	$1075.91	244.3	$4.42	$943.24	259.6	$3.63	$7944.13	862.1	$9.21	*	*	*	*	*	*
NEMC	$720.45	127.1	$5.66	$1040.43	123.1	$8.03	$1500.34	176	$8.52	$391.39	53.9	$7.27	$147.16	30.7	$4.80

NEMC	£1123.64	125.5	£8.95	£1055.21	165.9	£6.36	£5606.61	361.1	£15.52	£68.49	72.5	£.94	*	*	*
NEMCC	£102068	150.1	£6.79	£288.40	293.8	£2.80	£2126.61	44.7	£7.12	£44.49	*	£.99	*	*	*
NEMC	£2527.36	363.8	£6.94	£1746.13	360.7	£4.84	£2164.71	403.7	£5.35	£282.91	95.1	£2.27	£192.06	66.4	£1.15
N I	£2378	525.1	£4.53	£1142.20	140.8	£8.11	£3871.70	474.6	£8.15	£588.80	62.5	£9.42	*	*	*
N I	£880.40	115.2	£7.64	£782	189.4	£3.40	£2971.60	218.4	£13.60	*	*	*	*	*	*
N I	£5757.86	569.4	£10.55	£8799.19	1000.3	£8.79	£60629.02	1968.6	£30.29	£2054.42	398.7	£5.15	£210.67	162.4	£12.35
W I	£710.33	247	£2.87	£580.14	59	£9.83	£1482.16	103.5	£13.53	*	*	*	£219.96	13.5	£16.29
(6) W I	£443.85	478.1	£.93	£863.63	301.8	£2.86	£713.36	336.8	£2.12	*	*	*	*	*	*
W I	£195	140.5	£1.38	£140	16.6	£8.43	£730	135.4	£5.32	*	*	*	*	*	*
(7) W I	£1135.20	861	£1.31	£796.34	621	£1.28	£3198.01	373.3	£8.56	£337.06	317.06	£1.05	*	*	*
(8) S I	£1766.66	202.6	£8.72	*	*	*	£1166.66	278	£4.20	*	*	*	*	*	*
(9) S I	£87.50	46.2	£1.90	£63.30	16	£3.96	£1000	79.1	£12.64	*	*	*	*	*	*

Notes:-

* = No Data

(1) = 16 years only

(2) = 7 years only

(3) = 1 year only

(4) = 9 years only

(5) = 8 years only

(6) = 8 years only

(7) = 2 years only

(8) = 5 years only

(9) = 8 years only

Northern Womens College

subject discussed and in section VI of the paper dealing with the encouragement of science instruction. Little else can be suggested except that certain science subjects may be out of joint with the times, and may attain future success with greater or less modification of their present subject matter or in combination with other branches of learning as has been the case in sociology.

VI. Science in Southern Women's Colleges.

It appears from the available statistics that enrollment in science courses at southern women's colleges is increasing in the subjects of zoology, botany, physiology, physiology and hygiene, general biology, physics, and chemistry. This is in accord with the fact that increasing numbers of students of southern women's colleges are preparing to enter the professions and occupations, which previously in the South were largely confined to men, and is also indicative of the South's advance in the educational fields. Physiology and hygiene and botany, old favorites in the curriculum of the southern women's colleges still remain as such, but as compared with their sister colleges of New England, they show a greater proportionate gain in general biology, zoology, botany, physics, and chemistry, while interest in astronomy and geology seem to be increasing the most in New England women's colleges. As compared with the two women's colleges of the North for which data is available the gain in science registration is greater in the southern women's colleges.

VII. Encouragement of Science Instruction in American Colleges and Universities, 1912-22.

Presumably if science instructors have the proper equipment, apparatus, and supplies for teaching their courses and carrying on the research so essential for the actively minded teacher, then the institution itself will have done all in its power to encourage the progress in enrollment for science study. The rest depends on the capability of the instructors, and these should not be misjudged if any of these prerequisites are lacking. It follows that a convenient index for determining the encouragement given science instruction in colleges and universities might be obtained from the study of the appropriations granted their scientific departments over a period of years. Accordingly the same institutions which had received questionnaires concerning their science enrollments were asked also to specify the amounts furnished their scientific departments for apparatus and equip-

ment. Twenty-two institutions responded in one way or another. For obvious reasons the names of these institutions are not given on the accompanying table, but are designated by their geographical location instead.

The results presented in table IV, were obtained in the following manner. The average yearly appropriation in the given science at a particular institution was calculated for the ten years 1912-22. Next the average yearly enrollment in the science was obtained similarly. The former divided by the latter gave the average yearly amount per student spent for apparatus and equipment in the institutions whose statistics were studied.

It would be useless to pretend that such a method does not involve serious error from the standpoint of the college accountant, yet, to individual science teachers who may watch their own deficient or liberal appropriations, the statistics cited will have their interest. In order, however, that the reader may fully have in mind considerations preventing too broad an interpretation of the data, the following are cited as possibly affecting its accuracy.

1. Sums chargeable to equipment, and apparatus at some institutions may be accounted for under a different category elsewhere. Thus equipment such as tables and other furnishings may be considered as part of the charges accruing against a particular building rather than a department. In short there seems to be no system of procedure with regard to these practices in common usage among institutions. Hence the basis of comparison among different institutions is not the same. To avoid any further confusion here, the questionnaire sent the institutions did not ask for the sums appropriated for supplies, since these would ordinarily be cared for by the laboratory fees of the student, or the money appropriated for such purposes returned as the students purchased them. It is possible, however, that the information furnished the writer, as to the amounts appropriated in chemistry for equipment and apparatus include also appropriation for supplies. Apparently few college treasurers keep separate accounts for them.

2. Sums reported to the writer as chargeable to supplies, equipment, and apparatus may include funds used for both research and teaching purposes, while only in the latter usage are they pertinent to the subject we are now discussing. In other cases, funds ostensibly set aside for teaching purposes may

be expended for research equipment. In this connection however, it is well to remember that when financial grants are made for research purposes, such more often indicate that other demands have been satisfied, and according to best professional criteria reflect excellent teaching conditions. On the other hand it has often been said that many research scientists are not anxious to have a large number of students, a condition which will necessarily affect the enrollment in the sciences, and this is indicative of the fact that not all funds appropriated for a science work actively for its educational progress.

3. In the case of at least one institution whose appropriations were thus analysed, fire destroyed some of the scientific laboratories and these have had to be refitted absolutely anew, a circumstance which would lend to increase the appropriation beyond the normal amount they might require for efficient teaching.

The above are only some of the factors which inhibit too broad generalizations from the data presented, and indicate the difficulty of forming an accurate idea as to the support given science instruction at institutions as a whole.

If then, there are cases in which the teaching side of the sciences are unfairly treated by those in charge of them, there are others in which the blame is more equably placed on administrative authorities. For example, in many institutions laboratory fees are collected to provide for the costs of materials used by the student, or even ostensibly for the wear and tear on the laboratory and its apparatus. Sometimes these may not only be out of proportion to the actual outlay caused by the conditions they are supposed to meet, but in addition they may revert to the general fund of the institution rather than to the credit of the department which has caused them to be collected. The teaching staff then must take its chances about getting them back in equivalent appropriations. The better institutions are tending to eliminate laboratory fees as such, and make other provisions for the situation they were intended to meet.

For the above reasons the writer prefers to leave the interpretation of the table on financial statistics to the teachers and administrative officers in whose hands the article falls as having the most significance when compared with their own data under their own special conditions. However, it may be in place to dwell shortly on the facts shown by the analysis of these financial statistics as brought out in the shorter following table.

It is first remarked that the writer has some evidence one way or another of a research atmosphere at those institutions where appropriation is above the given average for the particular science, especially for those institutions approaching the maximum cited. However, he is unable to state positively that the converse is true of all those institutions below the average and approaching the minimum. The next comments affect the biological sciences with which the writer is most familiar. His personal estimate is that if the average of $6.36 shown by the table represents the sum devoted to the purchase of apparatus and equipment such is at best only a fair amount when one considers the necessity of replacing worn out microscopic equipment, the needs of the biological museum, and illustrative material for teaching purposes. If, as is probably its case with much of the data, the sum should also provide for expendable materials used in class work, it is far from being sufficient to provide the instructor with the best aid for teaching his science, even if the instructor saves some of the cost by collecting his own material. If the laboratory fees which may be collected do not revert immediately to the credit of the department, it takes but a comparatively short time for the laboratory to go down hill. Finally, when a biology department is compelled to get on with much less than that amount as indicated in the minimum, serious doubts must arise as to whether the instruction is fulfilling acceptably the spirit of the requirements of this science for professional schools. Such a point might also be raised in connection with physics and chemistry by those more qualified to judge.

The next table, V, concerns an attempt to correlate increasing or decreasing enrollments in science with the amounts of appropriation given. Within the limits of these statistics as already emphasized, the amount of appropriation granted in biology has little effect either way in affecting the enrollment in that science. Perhaps liberal appropriations might be construed as favoring an increasing enrollment, but one factor affecting the situation is that of the encouragement given research rather than teaching in certain institutions.

In the case of physics and chemistry, gains in enrollment are correlated with greater appropriations, but in chemistry alone more institutions which had less than the average appropriation show a gain rather than a loss. This is possibly attributable both to the keen interest in teaching problems which chemists are beginning to show as well as the greater public interest in

chemistry than any other science. The remaining sciences, geology and astronomy consistently show losses regardless of the appropriation granted. Factors possibly causing this situation have already been discussed in the preceding pages of this paper.

TABLE V. APPROPRIATIONS—APPARATUS AND EQUIPMENT ONLY.

No. of Institutions	Subject	Av. Annual No. Students 1912-1922	Av. Annual cost per Student	Max. cost per Student	Min. cost per Student	Instit. above Av. Approp.	No. Instit. below Av. Approp.	No. In. above Av. Ap. Showing Gain	No. In. above Av. Ap. Showing Loss	No. In. below Av. Appr. Showing Gain	No. In. below Av. Appr. Showing Loss
20	All Biology	318.3	$ 6.36	$15.79	$ .93	10	10	5	5	5	5
19	All Physics	226.9	$10.98	$32.77	$1.28	5	15	3	1	7	8
20	All Chemistry	351.7	$12.68	$33.28	$2.12	7	13	6	1	9	4
10	All Geology	128.38	$ 6.23	$27.11	$ .51	3	7	1	4	1	4
5	Astronomy	88.5	$ 5.00	$12.35	$1.15	1	4	0	0	1	4

UNITED STATES LEADS FRANCE IN PER CAPITA USE OF ELECTRICITY.

Interesting figures comparing the production of electricity in the United States and France are shown in a statement just issued by the Geological Survey of the Department of the Interior. According to a report recently published by the French Minister of Public Works, the amount of electricity produced for distribution in France in 1923 was 7,490,000,000 kilowatt-hours. Public-utility plants in the United States in 1923 produced 55,674,000,000 kilowatt-hours, about 7 1-2 times the total amount produced in France. The population of France in 1923 was about one-third that of the United States. About 46 per cent of the French output was produced by the use of water power, but only 35 per cent of the output in the United States was so produced. The per capita use of electricity in France in 1923 was about 200 kilowatt-hours; in the United States it was about 515 kilowatt-hours, or more than 2 1-2 times as much as in France. These figures include electricity imported to each country.

The potential water-power resources of the United States available 90 per cent of the time amount to about 35,000,000 horsepower, and the capacity of water wheels of all sizes installed in water-power plants in 1923 was 10,000,000 horsepower. France with potential water-power resources amounting to only 5,400,000 horsepower, had water wheels with a capacity of 2,100,000 horsepower installed in water-power plants in 1923. Taking into consideration the relative water-power resources of the two countries, France in 1923 was making much better use of her water-power resources than the United States.—*Science Service.*

HOW TO MAKE HIGH SCHOOL ZOOLOGY MORE ATTRACTIVE TO THE STUDENT.

By Amer M. Ballew,

Austin High School, Chicago.

In a recent survey made by Dr. Counts[1] of the curriculum offerings of fifteen representative cities of United States, it was brought out that the biological sciences occupy an inferior position at the present time.

In regard to zoology, Dr. Counts found that the emphasis was placed on structure and classification of animals. Human interest as opposed to scientific interest received comparatively little consideration.

The reasons for emphasis upon structure and classification can be accounted for largely by the type of training received in the colleges and the organization of most zoology textbooks.

The newer and more usable textbooks have been written for a course in biology. In zoology two of the more widely used texts were written in 1906 and 1913. It is evident that the zoology textbooks are not well adapted to the changing conceptions of education.

We have made much progress in the science of education in the past twenty years. We are beginning to analyze the child's interests and to adapt the curriculum to those interests. We are getting away from the idea that material which is difficult and distasteful to the child should be mastered for its mental discipline.

All teachers of biological sciences should deplore the fact that their subject occupies an inferior position in the senior high school curriculum. It certainly cannot be said that the subject matter of the biological sciences is of less value than that of the physical sciences.

It would seem fair to assume that most of the biological courses as taught at present lack human interest. The materials are organized about the interest of scientists rather than about the interests of high school boys and girls or of ordinary persons. It should be possible for teachers to correct this situation by conscious effort in spite of the type of training offered by colleges and the organization of most textbooks.

In the Austin High School we offer a year of zoology as an

[1] Counts, G. S., The Senior High School Curriculum, University of Chicago Supplementary Educational Monograph, 1926.

elective for the three upper classes of students. The writer has long been dissatisfied with the type of material in most zoology textbooks and has spent considerable time in organizing the course so that it might appeal to the human interests of students and give them some useful material concerning the animal world.

In order to determine whether the course was really proving interesting and enjoyable to the students the writer recently gave out a questionnaire to all of his classes that had finished one semester of vertebrate zoology.

It should be stated that in the Austin High School we attempt to have as many living animals in the laboratory as possible. These are taken care of largely by the students and come to be regarded as pets by the various classes. This is one of the best ways of appealing to student interests.

Considerable time is spent on birds. They are studied by means of bird skins and bird guides. This work is supplemented by lantern slides.

We have collected considerable usable reference material for use in the laboratory. Reports are given by students on topics in which they are interested. These reports are given about topics which will stimulate class interest and discussion. The care of pets never fails to prove interesting and practical to most

TABLE I.

Subjects Selected by Pupils as Most Interesting.

Subject	Boys	Girls	Total
Fish	5	3	8
Amphibia	1	0	1
Reptiles	3	10	13
Birds	10	18	28
Mammals	19	11	30
Historical Development	4	1	5
Total	42	43	85

TABLE II.

Reports Selected by Pupils as Most Interesting.

Report	Boys	Girls	Total
Goldfish	2	2	4
Geological Periods	5	4	9
Snakes	5	6	11
Bird Migration	3	4	7
Mammals	7	6	13
Dogs	7	6	13
Horses	5	4	9
Gorilla-Chimpanzee	8	11	19
Total	42	43	85

TABLE III.

Number of Pupils Who Enjoyed Subject of Zoology.

Boys		Girls		Total	
Yes	No	Yes	No	Yes	No
38	4	41	2	79	6

TABLE IV.

Reasons for Not Liking Zoology.

Reason	Boys	Girls	Total
Geological Periods Too Difficult	1	0	1
Too Much Writing	1	0	1
Way the Subject is Dealt With	1	0	1
Too Much Work	1	0	1
Did Not Like Science	0	1	1
Useless Subject	0	1	1
Total	4	2	6

TABLE V.

Changes Pupils Would Like to Have Made in the Course.

	Boys	Girls	Total
Fewer Drawings and Notes	6	9	15
More Time on Specimens	4	7	11
More Class Trips	5	2	7
Less Time on Birds	1	1	2
More Time on Lower Primates	1	0	1
Dissection	4	2	6
No Changes	10	8	18
Have More Periods	1	0	1
Moving Pictures of Animal Life	1	0	1
More Time on Mammals	2	1	3
More Study of Animals of Chicago District	1	1	2
Class Work Out Exercises Together	1	1	2
Have Laboratory Work Once a Week	2	1	3
Omit Laboratory Work	2	2	4
More About Habits and Life	1	0	1
Leave Out Historical Development	0	2	2
Omit Study of Snakes	0	1	1
More About Development of Human Race	0	1	1
More Reports	0	3	3
More About Internal Organs	0	1	1
Total	42	43	85

students. It is surprising how many city people have pets of various kinds.

We have no dissection. It is believed that the little knowledge of structure that is needed can be obtained better from good charts and models. Dissection is repulsive to most girls and tends to destroy their interest in the subject.

Tables I to VII inclusive represent the tabulation of replies of the students to the various questions of the questionnaire.

TABLE VI.

Has a Study of Zoology Changed Your Attitude Towards Animals?

Boys		Girls		Total	
Yes.	No	Yes	No	Yes	No
34	8	40	3	74	11

TABLE VII.

Ways in Which Study of Zoology Has Changed Pupil's Attitude Towards Animals.

	Boys	Girls	Total
Less Fear of Snakes	2	11	13
Ability to Recognize Birds	2	0	2
Knowledge of Animal Habits	7	5	12
Economic Value of Animals	2	0	2
More Friendship Towards Animals	8	12	20
Appreciation of Primates	1	0	1
Identification of Animals	2	2	4
Appreciation of Evolution	4	2	6
Superstitions Concerning Animals	6	8	14
Total	34	40	74

Some of the more important conclusions derived as a result of this study are as follows:

1. The pupils are most interested in mammals, birds, and reptiles. They are least interested in the historical development of zoology, fish, and amphibia.
2. The reports which proved most interesting were, gorilla, chimpanzee, dogs, mammals and snakes.
3. Six students out of eighty-five did not like zoology. Four were boys and two girls.
4. Some changes suggested by the students were, fewer drawings and notes, and more time on specimens. These are well worthy the consideration of every teacher.
5. Seventy-four stated that the study of zoology had changed their attitude towards animals. It should be noted that out of the eleven who answered in the negative many stated that they already had a love for animals.
6. Some of the more important changes in attitudes towards animals were: less fear of snakes, knowledge of animal habits, more friendship towards animals, and a knowledge of superstitions concerning animals. These attitudes should certainly represent some practical objectives for high school zoology.

This investigation has brought to light several things which the writer will attempt to remedy in his course. It is believed that a study of this kind is well worth the time and effort of every science teacher. It is not always safe to trust our adult judgment in the selection of subject matter as expert as we often think that it is. Student analysis will help us to adapt the subject of zoology to the interests and capacities of our students. The enlightening frankness of the replies to a questionnaire of this nature will prove a stimulus to every real teacher.

A PROBLEM AND SOME UNEXPECTED ANSWERS.

By Wilhelm Segerblom,

Phillips Exeter Academy, Exeter, N. H.

To amuse my second year chemistry class which had a little knowledge of Qualitative Analysis, I recently gave out the following problem on alum for outside study. The answers passed in showed considerable ingenuity on the part on the students. It therefore seemed worth while submitting it for publication in case any other teachers might care to try it on their classes.

Problem: Crystallized potash alum, $K_2SO_4.Al_2(SO_4)_3.24H_2O$, is made by evaporating a solution containing alum. This solution is made by mixing a solution containing potassium sulfate with a solution containing aluminium sulfate, the weights of the salts taken being in the proportion of their molecular weights. Outline a method for starting with crystallized potash alum, dissolving it in water, and then separating the two sulfates from each other so as to get in one dish dry crystallized potassium sulfate, K_2SO_4, and in another dish dry crystallized aluminium sulfate, $Al_2(SO_4)_3.18H_2O$. Write equations wherever possible.

Solution No. 1. Only one student passed in the solution expected, which was substantially as follows:

1) Dissolve the crystallized potash alum in water.

2) Add ammonium hydroxide to complete precipitation, but not in excess.

3) $K_2SO_4.Al_2(SO_4)_3.24H_2O+6NH_4OH=2AlO_3H_3+K_2SO_4+3(NH_4)_2SO_4$.

4) Filter; dissolve the precipitated aluminium hydroxide in dilute sulfuric acid.

5) $2AlO_3H_3+3H_2SO_4=Al_2(SO_4)_3+6H_2O$.

6) Evaporate to crystallization.

7) $Al_2(SO_4)_3+18H_2O=Al_2(SO_4)_3.18H_2O$.

8) The filtrate from (4) contains potassium sulfate and ammonium sulfate in solution. Evaporate this filtrate to dryness. Any possible excess of ammonium hydroxide goes off with the steam.

9) Heat the residue till the ammonium sulfate has volatilized off as white fumes.

10) Dissolve the residual potassium sulfate in water and evaporate to crystallization.

11) The crystals consist of K_2SO_4. Expose them to warm air to dry them.

Solution No. 2. The majority of the class attempted to separate the aluminium from the potassium by adding potassium hydroxide to precipitate aluminium hydroxide. Most of these neglected to take the precaution to avoid an excess of the potassium hydroxide in which the precipitate is soluble. Three members got around this difficulty by first calculating the exact amount of potassium hydroxide necessary to precipitate the aluminium. One student expressed it substantially as follows:

1) Let x equal the number of grams of alum used.

2) The amount of aluminium sulfate used equals

$$x \cdot \frac{\text{molecular weight } Al_2(SO_4)_3}{\text{molecular weight Alum}} = X\frac{342}{948} = 0.36x$$

3) Let y equal the number of grams of potassium hydroxide needed to react with $0.36x$ grams of aluminium sulfate. This comes out 0.355 grams.

4) Dissolve 0.355 grams of potassium hydroxide in water and add it to a solution of x grams of alum in water.

5) $K_2SO_4.Al_2(SO_4)_3 + 6KOH = 4K_2SO_4 + 2Al(OH)_3$.

6) Filter. Evaporate the filtrate to crystallization to get the potassium sulfate. Dissolve the precipitate in sulfuric acid and exaporate to crystallization.

Solution No. 3. Three students worked out the following method:

1) To a solution of alum in water add barium hydroxide solution and filter. The precipitate will contain barium sulfate and aluminium hydroxide. The filtrate will contain potassium hydroxide, and any excess of barium hydroxide.

2) $K_2SO_4.Al_2(SO_4)_3 + 4BaO_2H_2 = 4BaSO_4 + 2AlO_3H_3 + 2KOH$.

3) The filtrate may be neutralized with sulfuric acid, the barium sulfate made from the barium hydroxide filtered off, and the filtrate containing potassium sulfate evaporated to crystallization.

4) The original precipitate treated with sulfuric acid will give aluminium sulfate in solution, from which solution the crystallized salt may be obtained by evaporation.

5) $BaSO_4 + 2AlO_3H_3 + 3H_2SO_4 = BaSO_4 + Al_2(SO_4)_3 + 6H_2O$.

Solution No. 4. One student devised the following method:

1) Add ammonium sulfide and filter off the precipitated aluminium hydroxide.

2) $K_2SO_4.Al_2(SO_4)_3 + 3(NH_4)_2S + 6H_2O = K_2SO_4 + 3(NH_4)_2SO_4 + 2AlO_3H_3 + 3H_2S$.

3) Add sulfuric acid to the precipitate till it dissolves, and crystallize the aluminium sulfate.

4) Heat the filtrate to drive off the ammonium sulfide. Then heat it above 378° to break up the ammonium sulfate. Potassium sulfate is left.

A SUCCESSFUL BUSINESS.

By Helena Lorenz Williams.

An undeniably successful venture in public service is the Christmas seal sale which is held annually throughout the country and which is again before us. Like all big business enterprises, its growth is due to the commonly prescribed rules for success; namely, vision, hard work, thrift, and giving the public what it wants.

Within twenty years this undertaking, which is the chief support of the national, state and local tuberculosis associations of the United States, has developed from a $3,000 business to one whose gross receipts in 1925 were approximately $4,900,000. From a tiny hospital for tuberculosis patients in Delaware which was financed by the first $3,000 in 1907, it has become the means for creating a network of sanatoria, hospitals, open air schools, clinics, and other public health activities that protect the American people against what was once known as the Great White Plague.

According to the National Tuberculosis Association, the mother of this gigantic movement, the Christmas seal sale finances approximately 1500 state and local organizations besides the National Association. The united efforts of these have resulted in the establishment of 700 sanatoria and hospitals, with nearly 70,000 beds for tuberculosis patients; more than 1000 open air schools; nearly 12,000 public health nurses; and over 600 clinics. In addition, children's camps and preventoria, nutrition classes and numerous special campaigns such as Baby Weeks, Anti-Spitting and Open Window campaigns are made possible by these little penny stickers.

All but 5 per cent of seal sale money is spent in the communities where it is raised. The 5 per cent goes to the national body which acts as a clearing house for information, supplies, leadership, research and expert service for its affiliated organizations, and for the other allied institutions and agencies.

Altogether, the record of the tuberculosis Christmas seal inspires the confidence and continued patronage of its millions of supporters.

CLOSEST TO NOTHING.

A new approach to absolute nothing, a vacuum so nearly complete that only enough free gas is left in it to cause a pressure of one billionth of a millimeter of mercury, or approximately one fifty-billionth of a pound per square inch, was reported by a woman scientist of Vienna, Mme. Anna Schiermann. The usual procedure in obtaining high vacuums is to introduce specially prepared carbon, which absorbs the remnants of the gasses not removed by the powerful air pumps. For this carbon Mme. Schiermann substituted tungsten filaments, which proved much more efficient.—*Science Service.*

CENTER OF MASS—A SIMPLE AUTOMOBILE PROBLEM.

By Wm. S. Franklin,

Massachusetts Institute of Technology.

Imagine a body to be acted on by one force only. Of course this single force may be the resultant of all the forces which do act on the body. Under what conditions does this single force produce pure translatory motion? The answer is, when the line of action of the single force passes through the center of mass of the body. This statement should, however, be inverted; *it is better to define the center of mass of a body as the point at which a single force must be applied* (the point through the line of action of any single force must pass) *if the single force is to produce pure translatory motion.*

This statement is somewhat difficult to illustrate experimentally because it is almost impossible to devise an arrangement in which only one force acts on a body. A stick is held loosely in one hand, struck sharply with a hammer, and allowed to fall. The force exerted on the stick by the hammer is, while it lasts, so large that all other forces exerted on the stick (the force exerted on the stick by the supporting hand and the force exerted on the stick by gravity) are negligible in comparison. Therefore, the force exerted on the stick by the hammer may be thought of as the only force acting on the stick. This force may produce a combination of translatory and rotary motion as in Figs. 1 and 3, or it may produce pure translatory motion as in Fig. 2. The arrow F in Figs. 1, 2 and 3 represents the large momentary

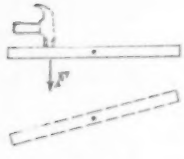

Fig. 1.

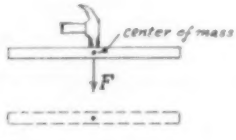

Fig. 2.

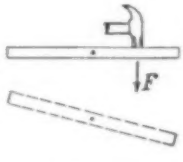

Fig. 3.

force exerted on the stick by the hammer, and when pure translatory motion is imparted to the stick the line of this arrow passes through the center of mass of the stick. The dotted lines show the positions of the stick a very short time after it is struck by the hammer and released by the hand.

Take hold of a long slim stick at its middle (at its center of mass), using thumb and forefinger, and move the stick up and down and to and fro in any complicated manner whatever, but without turning the stick. This motion is pure translation. Closing one's eyes, it feels as if one had a very heavy piece of lead between thumb and forefinger, that is to say, the material of the stick seems to be concentrated between thumb and forefinger (at the center of mass of the stick); but if one twirls the stick even to a very slight extent it no longer feels like a piece of lead between thumb and forefinger! This experiment must be tried to be appreciated, and it means that *a body performing pure translatory motion behaves as if all of the material of the body were concentrated at its center of mass.*

Center of mass and center of gravity are coincident. The center of gravity of a body is the point of application of the single force G which is the equivalent of (the resultant of) all the forces with which gravity pulls on the various parts of a body, and the observation that a body is never set rotating when it is let fall (except because of forces due to air friction which we are supposing to be non-existent) shows that the force G is also applied at the center of mass of the body in accordance with the above definition.

The Problem of the Starting Automobile.

A 3200-pound (100-slug[1]) automobile with its center of mass C located as shown in Fig. 4 is started on a level road with a forward acceleration of 6 feet per second per second. Find the tractive force F and the vertical pushes G and H of ground on front and rear wheels respectively. The friction at the hubs of the front wheels is to be neglected, and the torques required to set the wheels rotating are assumed to be very small and, therefore, negligible.

(1) The vertical forces which act on the automobile are balanced because the automobile has no vertical acceleration. Therefore, we have

$$mg = G+H \qquad (1)$$

(2) Look at an automobile standing still on a level road. Look at the car a moment later and it is seen to be moving for-

[1]When force is expressed in pull-pounds and acceleration in feet per second, per second, then mass must be expressed in slugs if we are to use the simple equation $F = ma$, the slug being the amount of material that would be accelerated at the rate of one foot per sec. per sec. by an unbalanced force of one pull-pound. Mass in sugar-pounds must be divided by the pure number 32.1740 to reduce to slugs. It is usually sufficiently accurate to divide by the pure number 32.

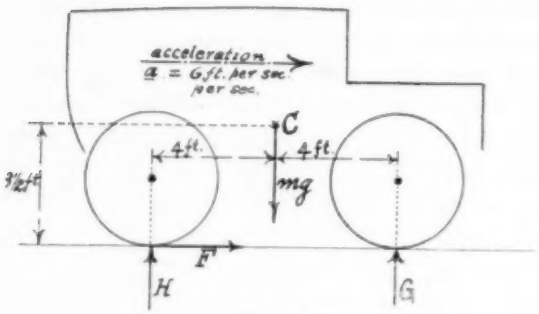

FIG. 4.

wards. What pushed forwards on the car to set it moving forwards? The ground is the only thing touching the car and capable of exerting a force on the car, and we may be sure that the ground exerted the forward push which set the car moving. A very accommodating ground! But what made the ground push forwards? The engine, driving the drive wheels, caused the rims of the drive wheels to push backwards on the ground, and if you push backwards on the ground the ground pushes forwards on you. This may seem fantastic, but it is not, it is a simple statement of actual facts. The forward push of the ground on the rims of the drive wheels is represented by the arrow F in Fig. 4 and this force is called the tractive force.

The tractive force F is the only horizontal force acting on the car, it is this force that is accelerating the car, and therefore

$$F = ma \qquad (2)$$

(3) What kind of motion is being imparted to the car? Pure translatory motion (rotation of wheels neglected). What single force could produce this pure translation? A single force whose line of action passes through the center of mass C, that is to say the actual forces mg, F, G and H which act on the car must be together equivalent to a single force passing through C. What torque action about an axis passing through C would a single force have whose line of action passes through C? No torque action whatever. What is the combined torque action of mg, F, G and H about an axis passing through C? Zero. Why? Because they are together equivalent to a single force passing through C. Therefore, reckoning torque actions (or force moments) about C, counting clock-wise torques as positive, we get

$$3\frac{1}{2}F+4G-4H = 0 \qquad (3)$$

Therefore, using $a = 6$ ft. per sec. per sec., using 30 ft. per sec. per sec. for g, the local acceleration of gravity (suppose it to be 30 ft. per sec. per sec.), and using 100 slugs for m, we get

$F = 600$ pull-pounds
$G = 1237.5$ pull-pounds
$H = 1762.5$ pull-pounds

NOTE: In this example, the acceleration of gravity being 30 ft. per sec. per sec., the true weight of the automobile (the earth-pull on the automobile) is 3000 pull-pounds ($= mg$) whereas the mass of the automobile is 3200 sugar-pounds.

The acceleration of gravity varies but slightly from place to place on the earth, so slightly, in fact, as to be of no practical consequence in many problems. The variation of the acceleration of gravity may, therefore, be wholly ignored in so far as the requirements of numerical precision are concerned, but it cannot be ignored insofar as the requirements of precise thinking are concerned. Numerical precision and precision of thinking are different things.

MEASURING THE SPEED OF LIGHT.

Chicago, October—On his return from a summer spent on Mount Wilson, Calif., in measuring the speed of light, Professor A. A. Michelson, former head of the Department of Physics at the University of Chicago, announced that the famous Michelson-Morley experiment of 1883, upon the negative results of which Einstein based his celebrated theory of relativity, would be repeated on Mount Wilson next December.

Professor Michelson said, also, that he had obtained very satisfactory results this summer, measuring the velocity of light as it travelled, reflected back and forth by means of a set of mirrors, from Mount Wilson to Mount San Antonio, twenty-two miles away. As a result of the experiment, it is expected that a much higher precision in the measurement of the light's velocity will be attained than has ever before been recorded.

Experts are now at work in Pasadena to perfect the interferometer, Professor Michelson's own invention, which he will use when he conducts once more the world-famous experiment which "involves the problem of measuring the speed of the earth and with it the whole solar system through space."

The interferometer devised by Professor Michelson was used by him in several important earlier investigations, notably, the establishment of the meter in terms of light waves, undertaken by Dr. Michelson in France at the request of the International Bureau of Weights and Measures; his measurement of the diameter of the red star, Betelgeuse; and the ether drift experiment of 1924-25 which studied the effect of the rotation of the earth on the velocity of light, confirming on completion certain parts of the Einstein theory.

CURRICULUM STUDY IN ASTRONOMY.

By Erma M. Krank.

Montevideo, Minn.

Under the supervision of and using the technique of Dr. S. R. Powers, Teachers College, Columbia University.

Purpose of this Study.

The general purposes of the school as conceived by Briggs[1] are two: first and fundamental, to teach pupils to do better the desirable activities that they will perform anyway; and, second, to reveal higher types of activities and to make these both desired and to an extent possible.

This study sets out to determine which phases of astronomy are desirable and inevitable activities for the child of the junior high school age, to determine the relative importance of this list, and to propose an outline whereby not only these but, also, higher types of astronomical activities shall be revealed and made reasonably possible in the general science course of the junior high school.

The Readers' Guide.

A count from the titles of articles pertaining to science in The Readers' Guide of 1922-24 revealed 15,448 listings about some phase of natural science.

Note: It does not follow that there were this many articles, for some were listed by both author and title and titles are frequently listed under more than one letter.

6,350 listings (41%) pertained to some phase of physical science and 223 (less than 1.5%) to astronomy alone.

Harap's Study.

The study made by Harap[2] indicates that the layman (consumer) has no need for astronomy.

Courses of Study.

The results of an examination of ten Courses of Study[3] that were taken from various parts of the United States are given in the accompanying table. I found that the Earth's relation to the Universe was mentioned in all of the Courses of Study. Some aspect of the sun was, also, considered essential in the teaching of science by most of the course makers, while an understanding of Northern Lights and Observatories was overlooked altogether.

[1]Briggs: The Junior High School, P. 157.
[2]Harap: Education of the Consumer.
[3]Minnesota (State); Richmond, Virginia; New York City; Los Angeles, California; Columbus, Ohio; Bayonne, New Jersey; Indiana (State); Newton, Mass.; Oregon (State); Kansas (State).

Textbooks.

An examination of six widely used general science textbooks[4] showed that certain phases of astronomy are included in all of them while certain other phases such as tides, Northern Lights, and Milky Way are not considered of sufficient importance to be included in the subject matter.

Pupils' Interests.

A study by Pollock[5] of questions asked by children of the Junior High School on matters pertaining to science reveals that out of 3,500 questions 975 (nearly 28%) were in the field of astronomy.

Curtis[6] made a similar study and found that out of 3,330 questions asked by 687 children 879 (over 26%) pertained to astronomy.

By assimilating the above data it may be seen that in all the 6,830 questions 1,854 (27.15%) were in the field of astronomy.

Magazine Articles.

Out of the 104 magazines[7] examined 47 articles on astronomy were found, totaling somewhat more than 13,700 words. This makes an approximate average of 300 words per article and a little fewer than one article on astronomy to every two magazines examined.

Newspapers.

Of the 630 newspaper articles[8] studied by Curtis 13 (2.1%) pertained to astronomy. The table in this study gives the number of articles in which astronomy was referred to rather than the number of articles which deal, primarily, with phases of astronomy.

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[4]Bowden: General Science with Experiments and Project Studies. Webb and Didcoct: Early Steps in Science. Hunter and Whitman: Civic Science in the Home and Community. Van Buskirk and Smith: Science of Everyday Life. Caldwell and Eikenberry: Elements of General Science. Pieper and Beauchamp: Everyday Problems in Science.

[5]C. A. Pollock: Children's Interests as a Basis of What to Teach in General Science. Educational Research Bulletin, Bureau of Educational Research, Ohio State University. Vol. 3: pp. 3-6.

[6]F. D. Curtis: Some Values Derived from Extensive Reading of General Science. Teachers College, Contributions to Education. No. 163.

[7]Outlook: May 5, 1926—July 21, 1926 inclusive. St. Nicholas: January 1925—July 1926 inclusive. World's Work: November 1925—August 1926 inclusive. Ladies Home Journal: March 1926—June 1926 inclusive. Review of Reviews: September 1925—August 1926 inclusive. Popular Science Monthly: March 1926—August 1926 inclusive. Science News Letters: April 17, 1926—June 26, 1926 inclusive. July 10, 1926 and July 17, 1926. Atlantic Monthly: July, 1925—June, 1926, inclusive. Scribner's: July 1925—July 1926 inclusive. Scientific American: April, June, and July 1926.

[8]Curtis: Op. Cit.

TABLE.

The Importance of Astronomy as Revealed by Analysis.

	Harap's Study	Courses of Study	Texts	Pupil's Interests	Magazine Articles	Newspapers
Astronomy	.....	4	6	31	.....	3
Comet	.....	4	3	21	1	1
Earth	.....	10	6	161	4	....
Eclipses	.....	4	4	29	3	....
Gravity	.....	4	5	164	....	3
Latitude	.....	5	3	3	....	....
Mars	.....	2	6	151	....	5
Meteors	.....	5	4	31	2	....
Milky Way	.....	1	2	3	1	2
Moon	.....	7	6	211	....	2
Northern Lights	.....	....	1	32	....	....
Observatory	.....	....	3	.....	1	2
Planets	.....	8	6	240	1	4
Rotation	.....	7	6	46	5	3
Seasons	.....	8	5	21	....	1
Sky	.....	3	6	37	3	....
Solar system	.....	8	6	30	1	2
Stars	.....	8	6	447	12	6
Sun	.....	9	6	167	5	2
Telescope	.....	3	5	.....	8	5
Tides	.....	5	2	29	....	4

CONCLUSION.

From the above investigation it may be seen that the children of the junior high school age are intensely interested in the field of astronomy which, probably, is the oldest of all sciences. Their natural interest in and their desire for information concerning such forces of nature are practically overlooked by newspapers and magazines. While 27.15% of the questions pertaining to science asked by children were in the field of astronomy only 2.1% of the newspaper articles on science and less than 1.5% of the magazine articles pertain to astronomy. Obviously, children's interest in astronomical phenomena, for their own sake or for more commercial reasons, are smothered rather than encouraged by these sources.

Although Harap's Study seems to indicate that the layman has no need for astronomy, it must be remembered that every time he looks at the calender or at the clock he is using the results of astronomical knowledge. However, in civilized countries, he need not determine the time of day or year astronomically.

Many of the textbook writers and makers of Courses of Study overlook the children's desire for astronomical knowledge. It may be seen in the Table that material for instruction is not always chosen on a scientific basis.

The following outline is presented for use in the general science course of the junior high school. It attempts to include the things that the children wish to know about astronomy and to reveal higher types of activities, in the science, which are likely to appeal to the children and be a basis for further inspiration and study.

UNIT ON ASTRONOMY.

I. Earth's Relation to the Universe.
  A. THE SUN.
    1. Original source of all energy upon the earth.
    2. Altitude and heating effect.
    3. How the air is warmed.
    4. Amount of solar heat.
    5. Source of sun's heat.
    6. Composition of the sun.
    7. Relative size and distance from the earth.
    8. The sun as the center of our solar system.
    9. Difference between stars, planets, and satellites.
    10. Gravity as the force which holds the heavenly bodies in their relative positions.
    11. Explanation of sunspots.
    12. Explanation of Northern Lights.
  B. THE MOON.
    1. Relative size and distance from the earth.
    2. The amount of light reflected from the sun.
    3. Cause of the phases.
    4. Its rotation and the lunar day.
    5. Its revolution and the lunar year.
    6. Appearance of the surface.
    7. Its climate.
  C. THE PLANETS.
    1. Number and names of the planets.
    2. Relative size, distance, and position.
    3. Their relation to the sun.
    4. Number of satellites.
    5. Distinguishing features of each planet.
    6. The planetoids.
  D. THE STARS.
    1. The sun is a star.
    2. Relative size, distance, and characteristics.
    3. Meaning of the term constellation.
    4. Recognition of: Great Bear, North Star, Arcturus, Small Bear, Vega, and Cassiopeia's Chair.
    5. Understanding of the Milky Way or Galaxy.
    6. The magnitude classification of stars.
    7. Use of the telescope to study stars.
    8. Use of the spectroscope.
    9. The use of star maps.
  E. THE COMETS.
    1. Characteristics of a typical comet.
    2. Nature of their orbits.
    3. Explanation of the tail action with respect to the sun.
    4. The evolution of a comet.
    5. Names of the more recent comets.
  F. THE METEORS.
    1. Characteristic features.
    2. Explanation of their light.

3. Meaning of term "shooting stars."

II. The Earth and its Motion.

A. The Size and Shape of the Earth.

B. Its Revolution.
1. Path of Earth's orbit.
2. Causes of seasons.
3. Meaning of the term equinox.
4. Meaning of the term solstice.

C. Its Rotation
1. Causes of day and night.
2. Varying length of day due to tipping of axis.

D. Time Measurement.
1. The sundial.
2. Understanding of the solar day.
3. Standard time belts of the United States.
4. International Date Line.
5. Daylight saving.

E. Eclipses.
1. Kinds of eclipses.
2. Causes of eclipses.
3. Frequency of appearance.

F. Meridians and Parallels.
1. Nature and use of meridians.
2. Nature and use of parallels.

G. Magnetism of the Earth.
1. Nature of the earth's magnetism.
2. The compass and its use.
3. Magnetism as distinguished from gravity.

H. The Tides.
1. Causes of tides.
2. Kinds of tides

I. Origin of the Earth.

HEALTH AGENCIES TO FIGHT SMALLPOX.

More cases of smallpox per year are reported by the United States than by any other nation in the world with the exception of certain parts of Asia. In an effort to redeem our country from this unenviable condition, the official health agencies of the several states have designated the months of November and December as a period of public enlightenment regarding the nature of smallpox and its prevention under the Seymour plan of the Association of State and Provincial Health Officers.

In time for this educational campaign, the American Association for Medical Progress has issued a revised edition of its pamphlet "Smallpox—a Preventable Disease." Among the new features of the revised publication is a table giving the vaccinal condition of over 10,000 smallpox cases for 1925 taken from the reports of 17 states and the District of Columbia, all for which reports are available. More than ninety per cent of these 10,000 persons afflicted had never been vaccinated; about seven per cent had been vaccinated seven to fifty years previously, leaving less than two per cent who had been vaccinated within seven years prior to their illness.

Copies of "Smallpox—A Preventable Disease" may be had upon request by addressing the American Association for Medical Progress, 370 Seventh Avenue, New York City.

A CONVENIENT RULE FOR LOCATING THE DECIMAL POINT IN SLIDE RULE CALCULATIONS.[1]

By Loyd C. Elliott.

Phoenix Union High School, Phoenix, Ariz.

In the physics classes of the Phoenix Union High School and Phoenix Junior College we introduce and encourage the use of the slide-rule. The methods we have previously used for determining the location of the decimal point have been inconvenient. They could not be easily carried in mind while the settings were being made if there were a number of factors. To help this situation I worked out the following rule.

In every single multiplication or division the indicator is set on one of the factors, and then the other is set with the slide, and the indicator is moved either left or right. The first step of this method is to count, in any series of multiplications and divisions, the number of times the indicator is moved to the left in making the settings. Movements to the right are ignored.

For example in 2×3, first set the indicator on 2 on the D scale, then set the slide to multiply by 3. It is immaterial whether the C, CI, CF, or CIF scale is used. It is also immaterial as to which direction the slide extends. Then move the indicator to the answer, which will be 6 on the D scale. The indicator is thus moved to the right.

In $\frac{2\times3\times4}{11}$ the indicator would, in the first multiplication, be moved from 2 to 6 which is to the right. In the second multiplication, it would be moved from 6 to 24, which would be left. This left motion would have to be counted. Then the division by 11 would be another left motion of the indicator. We would thus have two left motions for this calculation.

Having determined the number of left motions, the rest of this method is the following:

To the number of left motions of the indicator add the total number of places that are to the left of the decimal point in all the multiplication factors, and subtract those in all divisors. Then subtract the number of multiplication signs between the multiplication factors (those in the numerator). The figure thus obtained will be the number of places to the left of the decimal point in the answer.

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[1]Read before the 1926 meeting of the Southwestern Division of the American Association for the Advancement of Science.

For example, in the above calculation $\frac{2\times3\times4}{11}$ there were 2 left motions. To this must be added 3 for the places in the multiplication factors. Then subtract 2 for the places in the divisor. Then subtract 2 for the two multiplication signs between the multiplication factors. This is $2+3-2-2$ and gives 1 as a result. There must, therefore, be one place to the left of the decimal point in the answer. The slide rule shows the figures of the answer to be 218. Therefore the answer is 2.18.

Take another example, $\frac{21.8\times.145\times8.35\times2.42\times22.2}{386\times.126\times20.8}$ if all the multiplications are made first, and then all the divisions, the motions of the indicator will be as follows: R, L, R, L, R, L, L. This gives 4 left motions. Any other order of making the mulitplications and divisions would give the same result, of 4 left motions of the indicator. Then 4, +6 (for the multiplication factors), −5 (for the divisors), −4 (for the multiplication *signs*), gives a result of 1. The multiplication signs in the denominator are not taken into consideration. The slide-rule shows the figures of the answer to be 1401. The answer is then 1.401.

In cases such as the following: $\frac{7.85\times.0000048}{.0063}$, the method is the same except that zeros between the decimal point and the first significant figure, are counted as negative places. Making this calculation gives 598 with one left motion of the indicator. Then $1+(1-5)-(-2)-1$ gives −2. This indicates that there are 2 zeros between the decimal point and the first significant figure of the answer. The answer is therefore .00598.

It will be readily seen that the method can be used equally well in cases of a single multiplication or a single division.

When the folded scales are not being used the following facilitates the use of this method. In every case where two calculations are made at one setting of the slide, one will be a left motion of the indicator and the other a right. Therefore in every such pair of calculations, simply count 1 without bothering to notice which way the indicator is moving.

In case it is desired to apply the method when the DF scale is used, the following addition is necessary. Any right motion of the indicator that crosses the index in the center of the DF scale must be considered a left motion, and any left motion that crosses

this index must be considered right. The method can be applied to the A and B scales but it is not especially practical for these scales.

There is one exception to this rule, and that is a divisor having 1 as the only significant figure. For example 100, 10, 1, .1, .01, etc. If one of this type enters as a multiplication factor, the rule holds, but if it enters as a divisor it will fit into the rule only if the decimal point in it is first shifted one place to the left. However, it is easy to adjust for this type of number, either before or after the calculation is made, and so leave it out of the calculation on the slide-rule.

The value of this method of locating the decimal point lies in the fact that the counting of the number of left motions of the indicator can easily be carried in mind at the same time the settings are being made, and then simple addition and subtraction complete the method. Also a greater number of scales come under the rule, than with former rules.

A brief statement of the rule is as follows:

In each single operation of multiplication or division move the indicator once. Count the number of these motions that are to the left. To this add the total number of places that are to the left of the decimal point in all the multiplication factors and subtract those in all divisors. (In any number less than unity, any zeros between the decimal point and the first significant figure count as negative places.) Then subtract one for each multiplication (conveniently done by subtracting the number of multiplication signs in the numerator). The resulting number gives the number of places to the left (or, if negative, zeros to the right) of the decimal point in answer.

COLOR SYMPHONY CONCERTS.

A screen on which are projected fleeting colors may become an essential part of a symphony orchestra concert in the future, if a device devised by Alexander Laszlo, a musical composer of Munich, comes into general use.

Previous attempts to correlate color with sound and to produce a visual form of music have been made by the French composer Scriabine and others, but, it was stated, it is scientifically impossible to follow any relation between the wavelengths of light, which determine color, and of sound, which determine pitch. However, it can be done by correlating the light effects with the individuality of the composer.

The Laszlo apparatus makes use of six separate projectors, which operate in conjunction with a piano.—*Science Service.*

ION VISITS THE REALM OF AIR.

By J. A. Shelton,

Browns Creek District High School, Kimball, W. Va.

Cast of Characters.

1. Ion—A Wanderer, looking for "A MAN."
2. Chemist—Interested in the Affairs, Welfare and Understanding of Men.
3. Health—A Spokesman for Oxygen, Active, Energetic.
4. Nitrogen—The wise conservative councillor.
5. Water Vapor—The Governess.
6. Carbon Dioxide—A Builder of Plant Tissues.
7. Five silent characters—Argon, Helium, Neon, Krypton, Xenon, Inert, Useless, Rare.

(*Chemist on stage with test tubes, racks, and such chemicals as will change the color of solutions, readily evolve oxygen, and illustrate other chemical changes.*)

Chemist—My task is an unending one. I toil incessantly. My findings are recorded and passed to mankind to build up, to protect, to perpetuate, to edify. Can it be that my toils are without success in the form of a helping hand to my brother? Well, there is joy in the effort. . . . (*In meditation.*)

(*Taps at door arouse him. He moves slowly toward door with hands clasped behind him, head down in deep thought. Opens door.*)

Chemist—Sir, will you enter my meek and lonely habitation? (*Enters Ion.*)

Ion—I am Ion, the wanderer. Duty brings me to your fireside. For years and years I have wandered in effort to find "The Man."

Chemist—And, Sir wanderer, who is he whom you seek? Of course while it is necessary that I dwell alone, you will ever find me just. If I can be of any service to you I shall move at your bidding.

Ion—If you will but tell me something of your work and how it benefits mankind you shall have done for me the favor for which I call.

Chemist—Before I start, will you tell me who has started you to wandering and why you seek me in these quarters where few care to dwell?

Ion—You may know only that I am a wanderer seeking "The Man" who does the greatest deed for his kind. I have been here, there, everywhere. It has been mine to view the marvels of the inventor. I have heard expounded the theories of the philosopher and the doctrines of the theologian. The mathematician has juggled his digits for me. The musician has often eased weary

hours while the artist has raised my standard of living. I have interviewed many, many more. Now will you tell me to whom I speak?

Chemist—Doubtless you have found many whose deeds have elevated man. I do not know that my plane is higher. Yet, I have contributed my part. My history is a long one and my works have been many. I am the chemist. I help man in his industry, make more productive his soils; I enrich the home life of those who heed me, defend the land of the oppressed, and protect the health of all in order that man may enjoy happiness in his prosperity. During this call I can inform you briefly of my works.

Ion—Then, if you are to limit my information I wish to know first just what the chemist has discovered concerning the air about us which seems to be so necessary to our very lives.

Chemist—Your request shall be granted. I have discovered that the air is a mixture composed of two compounds and seven elements. Just now I cannot say that each of these nine parts has its distinct function in air—the atmosphere which surrounds us. However, I am inclined to believe there is a function for each part. My study of air has not ended, and until it does no definite and final announcement will be made concerning every constituent part of the air. Now you find me after having gained a distinct knowledge of some of these parts. A familiarity with some of the elements has been acquired. These shall speak for themselves. The mere application of heat to this substance (holds up test tube containing mercuric oxide) brings oxygen, not the most abundant, but by far the most important constituent of the air. Oxygen's results are evident.

(*Enters Health.*)

Chemist—Health, since you are here, speak to Ion as a living evidence of the importance of oyxgen to man's life.

Health—Ion, it is a great pleasure to tell you some of the good things oxygen does, and how it is made possible for you to wander in good health and happiness. I would like for every one to know. It is too important for me to take the time to tell those who neither care nor will take the time to tell others, therefore, before I start, you must make one promise.

Ion—My life is being spent in seeking "The Man" who does the greatest good for his kind. If your message is important I shall not only make the promise you ask, but I shall spread the news abroad.

Health—I desire that you be attentive to my story.

Ion—That I promise.

Health—Oxygen is everywhere. It always works and is the one thing of which man cannot get too much. In the body it plays A MOST IMPORTANT PART. It is carried in the blood and when it reaches torn-down cells it oxidizes—that is, burns, them. Then the burned cells are thrown off as waste. Oxygen also makes possible the generation of heat by oxidation and in this way maintains normal body temperature. This is necessary for good health. Oxygen also destroys destructive germ cells which find their way into the body and do untold harm when oxygen is not sufficiently abundant. In the air oxygen plays its part. When water is exposed to fresh air it is purified by oxygen and made fit for you, being thus freed of its harmful germs. When waste is deposited, oxygen, by a process of oxidation, causes it to decay thereby serving as a scavenger and maintaining more healthful surroundings for man. Further oxygen aids in combustion. In this way it is as useful and indispensable as the substances burned for light, heat, or other purposes. Much more could I tell you about oxygen and its relation to man—all of which would be a contribution to mankind, but I am sure Chemist has other advocates who are to tell you more about his work.

Ion—Health, I have enjoyed very much the information which you gave. I am sure the boys and girls with whom I come in contact will be just as interested as I have been.

(*Health exits. Chemist puts splint in oxygen bottle.*)

Chemist—While oxygen is indispensable to both plant and animal life, a great aid to the progress of man, and the historical foundation of my work, it is one of the boys who needs guidance, supervision, and a constant companion.

(*Enters Nitrogen.*)

Ion—Do you come to further interest me in the work of this mighty man, the Chemist?

Nitrogen—Yes, I am a product of his labors. He has found that I have a part to play in building the body, in feeding plants, in protecting nations, and in the general progress of mankind. Yet, before you are told of my function there is something more to be known about oxygen.

Ion—Health himself is such a convincing argument for the good of oxygen that there does not seem to be much else to be told.

Chemist—We could very well entertain you for an evening and

mention only oxygen, its use, and its work. All would be good. The information would be worth while. But oxygen must not be alone. He is so energetic, so active, and so congenial that it is necessary for him to have as a constant companion a wise, sturdy counsellor. This companion is Nitrogen.

Ion—How do you keep oxygen in check? How do you so successfully advise him that your companionship has never been broken?

Nitrogen—It is only in the air, where oxygen is free, that I accompany him. My presence decreases his energy, makes him less active, and so when his geniality would lead him to a union with the other products of the chemist I make the action less vigorous.

Ion—This, I suppose, is a big job and possibly it is your only duty.

Nitrogen—This is hardly the beginning of my labor. In union with other elements I have tasks which are always being performed, but are never completed, when this union is brought about I lose my identity. New substances are formed. These are very important. Some of them are the most powerful of explosives. Men who are ever ready to crush the weaker brother are held in check, and the rights of all receive consideration.

I am taken from the air by man and plant. Both of these join me with other elements making materials which give the soil greater productivity. In this way I feed all living organisms, form substances for constructive tissues, and hence serve when service is needed and where no known substitute can serve.

Ion—Then I can understand why almost four fifths of the envelop of the earth is given for you to fill. More light is made to shine upon my path. I have a second reason for considering Chemist as the man whom I seek.

Chemist—You are indeed interested in this work. If you will but speak, another one of mine will testify for herself.

(*Enters Water Vapor.*)

Chemist—I am glad you came. Ion wants to know more about the information I have given man, and I was just about to call you.

Water Vapor—I am known best as a colorless liquid but I am just as important as the invisible gas composing much of the earth's atmosphere. I am Water Vapor.

Ion—In the atmosphere, what do you do?

Water Vapor—I am the governess controlling evaporation and

making pleasant the habitation of man. The human body, plants, and the very crust of the earth itself contain water. This water is being given up almost constantly, increasing my volume in the atmosphere. Without me this surrender would soon dry the earth and the heat of the sun would make the earth a torturing, reflecting furnace; plants would lose their moisture only to be parched, soon to die; and man's comforts would be correspondingly affected. If this evaporation is too rapid the body loses much of its heat, causing chills. If this evaporation is too slow the air seems sultry; man becomes drowsy and inactive. In either case man is uncomfortable. So it is my duty to control this action for comfort and for preservation of life—and hence production and reproduction.

(*Enters Carbon Dioxide.*)

Ion—If there be others representing you as a blessing to man let them come. My journey has been long. My task has increased with the progress of man. I shall pass your way but once, therefore my information must be complete.

Chemist—I shall next have Carbon Dioxide to speak. His words are few, but his role is important.

Carbon Dioxide—In me plants find an essential food and their only supply of carbon. Carbon makes up a large part of the sugar, starch, and cellulose found in plants. Most of the woody tissue is carbon. This woody tissue forms the basis for much of the cloth, paper, food, and other articles necessary for the human race. The study of me together with compounds in which I am a constituent part is possibly the most complicated in the field of chemistry. To this study many chemists have given their lives. During this interview with you I have given the facts of my activities and service to man.

Chemist—Next, I shall present to you five of the very rare elements in the atmosphere. These for the most part are strange, inert, and, so far as my researches have gone, useless. There is no doubt, however, but that further study will reveal a place in the plan of the progress of mankind for each of them.
(*Enter Helium, Argon, Neon, Krypton, and Xenon.*)

Chemist—Of these Helium forced, in recent years, her admittance into the aeronautical world. It possesses the desirable features of being light, non-inflammable, and little affected by changes in temperature. Its rarity seemed to have been the puzzling problem which made it useless in previous years.

Argon is the most abundant of these. It does not work, exhibits no action, so no use for it has been found.

Neon, the newest element, is one of the company, but so far as is known, it is useless.

Xenon is strange, rare, and inactive.

Krypton seemed to have been so named because all its powers, if it has any, are hidden from man. Surely it may not have any, but study for the purpose of discovering its use has not ceased.

(*Exit Helium, Argon, Neon, Krypton, and Xenon.*)

Ion—Chemist, surely your contribution to man is unsurpassed. My travels began with creation. I have observed the work of all. Truly you are THE MAN. Now my search has ended. My purpose henceforth shall be twofold—praising the man of my objective, and imparting to the boys and girls I meet the information I have received here today. I shall tell them—if they would be wise, know the work of the chemist; if they would be appreciative, put the chemist first; if they would be remembered serve man.

BETTER CULTURAL BACKGROUND FOR CITY TEACHERS.

That 50 per cent of the principals and other supervisors of elementary and high schools and normal school faculties of the District of Columbia be employed each year from outside the District, in order to mitigate the deleterious effects of taking a large proportion of grade teachers from the normal schools of the District, is recommended by a committee of three specialists from the Bureau of Education of the Interior Department. These men recently made a survey of the two normal schools in Washington at the request of the board of education of the District of Columbia. It was further suggested by the committee and approved by the United States Commissioner of Education, Dr. Jno. J. Tigert, that all new appointees to teaching positions in normal schools should have received the master's degree and have at least 30 semester hours of professional work in addition to two years of supervised teaching experience.

It was recommended that the course of study of the normal schools be extended to three years in order to strengthen the educational and cultural background of the teachers. Other suggestions were that all high-school students who rank in the upper half of their classes for the last two years of high school, who can pass a strict physical examination and who rate high on personal qualifications score card shall be eligible to admission to normal schools; that high-school graduates who do not rank in the upper half of their classes but possess all other requirements shall be admitted on attaining a standard score in a standardized achievement or intelligence test; that provision for teacher training be made for all graduates of Washington high schools who are residents of the District of Columbia, without restrictions as to their future place of employment, provided they meet the requirements for entrance; and that scholarships be provided at public expense in local colleges and universities for graduates of Washington high schools who wish to become high-school teachers.—*Dept. of Interior.*

THE LABORATORY-PROBLEM PROJECT METHOD OF TEACHING GENERAL SCIENCE.

By Erma B. McCaffrey,

Lincoln Junior High School, Beloit, Wis.

The function of the school is to supervise and direct the pupils while they teach themselves. No one actually teaches another; the instructor puts the learner in the way of teaching himself. The value of the study lies primarily not in the facts acquired but rather in the habits with which pupils, through their own activities, become equipped for further work.

The generally accepted aims in the teaching of general science are:

To teach pupils to think scientifically.

To build up a body of information in general science in order to inable pupils to think clearly.

To acquaint the pupil with his environment both physical and biological.

To give the 1st year pupils an attractive view of the content of all the sciences so that they may find out where their particular capabilities lie; and more wisely choose what they wish.

To stimulate interest in science, and thereby keep alive interest in scientific progress.

To demonstrate to pupils the everyday need and use of science and the humanizing influence of the use of science.

To prepare pupils for the special science or sciences which they may elect later.

To impart information from the scientific standpoint about the useful and interesting things about us, especially for those who will not go to high school and college, and therefore would remain ignorant of scientific facts in the forces around them.

To train pupils in their ability to "assimilate" plain, concise, clear statements.

To train pupils in their ability to apply information in the solution of new problems or projects.

Realizing the above aims can best be accomplished by organizing a course in general science whereby:

The teacher will take an experimental attitude.

The subject matter will be made as interesting as possible.

The subject matter will not be too difficult—experiment will decide that.

The subject matter will build up about the child's present environment.

The subject matter will be so organized that the work will be satisfactory for an average class.

Actual problems will be solved in the school so pupils will attack the problems outside of school similarly.

Most problems in general science subject matter will deal with the complete situation in its natural setting.

The subject matter will have direct connection with the community's civic problems.

The General Science course will develop the historical nature of all of science.

The subject matter will be arranged in progressive order.

There will not be too great generalization on work in general science.

The course will be practical in that it will be broad.

The range of materials which can be used is limited only by the capacity,

experience and needs of the pupils. The materials should be concrete and capable of leading to avenues of new and untried experiences.

In organizing material the "Topic" is the large unit to which many specific pieces of work are related.

Problems or (projects) should be capable of demonstration either by pupils in individual or group experiments. The apparatus should be simple.

The project method of teaching General Science will help realize these aims as well if not better than any other method.

The project is a series or collection of problems. It is a challenge to the pupil to solve something he is interested in. The project should be practical enough to be solved by the same methods as the pupils are apt to use in adult life. The project is sometimes defined as a whole-hearted, purposeful activity.

Before we take up the project method of teaching in detail let us place before our minds the following arguments for the use of projects; let us bear these arguments in mind and throughout the remainder of the discussion see whether or not they are valid.

The project method as an application of laws of learning, follows the psychological rather than logical order in learning.

The project method recognizes individual differences in the native instincts of pupils and thus stimulates all classes.

The project method teaches the power of self direction.

The project method gives motivation; because perplexity or curiosity is the result of real desire for solution.

It gives natural setting as opposed to the artificial and thus gives unity.

It develops the reasoning power rather than mere memory.

The project method increases the ability of the pupil to collect, organize and use facts and theories.

It emphasizes priority of problem instead of principle.

The project method provides for the acquiring of skill and information needed in later life with a minimum of difficulty because of individual effort.

Project method organizes material from the social point of view, deals with natural situations and gives ability to share common life.

The suggestion and thought of the project should come from the pupil and probably is suggested from one of a multitude of problems which arouse the curiosity and interest in the scientific relations which will be called forth in working them out, and which pupils may be incited to set up as problems for solution.

The use of the project method gives the child a strong impulsive immediate motive for getting all of the possible information on a problem or question. The dominating purpose, as an inner want or desire to know, fixes the aim of the action, guides its process and furnishes its "drive" or its motivation. The project, then, is an expression of some desire on the part of a pupil; and the answering of this felt need by the solution of the problem by the child. If the projects are carefully guided, the content of the course will include what is most desirable for pupils to

learn. They are stimulated to learn things because they themselves want to know them and not because the teacher insists that they learn the material.

According to Prof. W. L. Eikenberry projects may be divided into four types as follows:

1. Construction Type.—Where the purpose is to embody some idea of plan in external form such as building a boat. Occasionally a project of this type may be of such character that it will lend itself to aid from several members of the class, e.g. setting up and operating a telegraph apparatus.

2. Appreciation Type.—Where the purpose is to enjoy some aesthetic experience as listening to a story or appreciating what some scientist has contributed to the world. These projects are closely related to the inspirational and recreative functions of education. The usage of such projects is wholly in the experimental stage.

3. Intellectual Type.—Where the purpose is to straighten out some intellectual difficulty, to solve some problem, as to find out whether or not dew falls.

4. Skill or Habit forming Type.—Where the purpose is to obtain some item or degree of skill or knowledge as learning the boiling points of the various liquids.

The above types embody the aims of 1, skill or habit forming; 2, knowledge; 3, appreciation; 4, construction. These have always been in the mind of the teacher. They have been sought through lessons, drills and recitations, but too often the purpose was that of the teacher and not that of the pupil. The project method does not dispense with textbooks, drills, references and recitations; it requires that these shall be engaged in, as a result of the pupil's purpose to secure certain skill, or knowledge which appears to them to be valuable rather than to engage in the same activities as assigned task.

Projects of types 3 and 4 are most usable in General Science.

The laboratory work is an essential part of the problem method. The laboratory is useful for illustrative purposes to secure for the children sense impressions from contact with objects, as a place for executing constructional projects and sometimes as a means for carrying out the search for information.

Working A Project.

1. What method would you use in having pupils select their project?

(a) Questions brought up by the pupils during class discussions or questions brought to class from outside by pupils (in the class) will often times furnish excellent projects. The pupils are very curious and will bring up project questions often. If they suggest the question, you may be very sure that they themselves are interested in the question or project, and interest is the principal motivation of a project. The teacher might post a list of projects on the bulletin board and allow the pupils either to select a project from the list or to add another project to the list and volunteer to solve it.

(b) The teacher will have to consider each project selected to see that the solution is possible by the student who has chosen it, considering his experience and subject matter of knowledge. The teacher must arrange conferences with the pupils who have selected doubtful projects, as well as have conferences with all of the pupils, to see exactly what phases of the subject they intend to work on and what method of attach they are going to use. It is the business of the teacher to decide whether the project selected is practical and valuable.

II. How should teacher and pupils organize their form of procedure?

(a) Teachers.

1. It is probably advisable to attempt only one or two series of individual projects during the year. The first one should not be launched before the latter part of the first semester, by which time pupils should possess a sufficient knowledge of facts and methods to undertake project work profitably.

2. The meaning of the word "project" should be introduced early in the course, in order that it may become a part of the child's vocabulary, and that he may fully appreciate its scope and meaning.

3. From time to time pupils will ask questions about certain phases of the subject which are not covered to their satisfaction in the work of the course. Suggest that members of the class consider these questions as possible projects. Other suggestions may also be made as they occur.

4. A definite date should be announced for the final selection of the individual project. The responsibility of weighing the value, and of choosing a practical, concrete project should be placed upon the pupil. He should also take into consideration the solubility of the problem to be solved.

5. In approving the chosen projects the teacher should discern whether the pupil has ambitions beyond his ability and arrange conferences with pupils whose choices are doubtful.

6. Hints and suggestions as to procedure and solution may be given. The class should be given the opportunity to ask questions and discuss the situation.

7. Keep in constant touch with pupils as they progress with their projects. Conferences should be arranged with pupils, at which time methods may be approved or corrections made. Let the pupil work out his own project, but set him straight in case he becomes confused or sidetracked.

8. The teacher must understand each project being worked out by pupils.

9. Direct pupils to keep project material for demonstration.

10. Set definite time for completion.

11. Be sure pupils understand that only neat work is acceptable.

(b) Organization of form of procedure (pupils) is as follows:

1. Selection of project. Choose a subject in which you are interested. Be sure it is practical and valuable. Is it reasonably possibly to solve? Are there materials with which to work?

2. Analysis of problem using information at hand. Division of project into problems.

3. Report to teacher.

4. Search for information and perform any necessary experiments. Remember that you will be expected to demonstrate your completed project to the class both orally and by means of appropriate charts or apparatus.

5. Organization according to analysis. Does the information you have obtained correspond with what you have previously learned? Can you verify your results by further experiments, or by reference, to establish facts? What principles of science have been illustrated in your work? Can you verify your result by further experiment?

6. Demonstrate and explain your project to the class. Be prepared to answer questions on work done in connection with your project.

III. How can the project work be made a part of the regular class work?

Approximately two days out of the week might be given over to the project work. During the time the pupils are working

projects have no regular class work except drills. Project work should be substituted for some of the regular class work at least.

IV. What difficulty may the teacher expect the pupils to have?

The pupil will probably have trouble in gathering his materials or in finding information in as great quantities as he wishes. The teacher can suggest places of information or places where materials can be obtained; or arrange for the pupil to visit places which are essential for completion of his problem. The pupil may also have trouble in arranging his project material, and a little suggestion on the teacher's part will boost him over the difficulty. The conclusion may also be a source of difficulty.

V. What conclusion should the teacher expect each pupil to make in his particular project?

A general conclusion, on information obtained, should be made in the light of the question or project solved. If the teacher has kept careful check on the projects as they progressed the results will not be very far out of the way. If the pupil sees or can readily be led to sense that he has a faulty conclusion, he will usually be anxious to remedy it and offer to do it over, profiting by his mistake.

VI. What method should be used in having each pupil demonstrate his project?

The demonstration of the projects will appear of more importance to the individual pupils if it is a public demonstration as well as having it given to the class. Some of the projects worked out by our pupils last year were:

1. Best type of boat for travel.
2. The history of the bicycle.
3. Collection of stamps.
4. To make out a well balanced diet for a school pupil (1 week).
5. Heart and circulatory system.
6. Telegraphy.
7. Of what use is protein to humans.
8. Classification of local flowers.
9. The moving picture.
10. To plan a model home.
11. Electricity and the home.
12. Electrical wiring.
13. Wisconsin birds.
14. Textiles.
15. Our solar system.
16. Construction of a boat.
17. Construction and wiring of a house for electricity.
18. History of development of weapons.
19. Salt.
20. Batteries.
21. Fire extinguishers.

22. History of matches.
23. Toy-making.
24. Types of lakes.
25. The vacuum cleaner.
26. Tree chart.
27. Flower chart.
28. Auto mechanism.
29. Iceless refrigerator.
30. How to repair a leaking faucet.
31. Fireless cooker.
32. Study of radio.
33. Electric magnets.
34. Heating our homes.
35. Air pressure.
36. Breathing.
37. Cooking of foods.
38. Building materials.
39. Evaporation.
40. Rocks.
41. Elasticity.
42. Capillarity.
43. Oxidation.
44. Time and clocks.
45. Machines.
46. Conduction, Radiation, Convection.

A. One project, "Heating our Homes," was worked out as follows:

QUESTIONS—HOW SHALL WE HEAT OUR NEW HOME?
Steps in development for child:

I. What kinds of heating systems are there?
II. Study of each system (collection of material).
  A. Study of hot air.
    1. Parts of the system and how the system is constructed.
    2. How system functions.
    3. Inspection of such a system while in operation.
    4. Advantages of such a system.
    5. Disadvantages of such a system.
    6. Conferences with several people who have such a system.
  B. Study of hot water system. (Follow Outline A.)
  C. Steam system.
III. How does each system distribute the heat?
  1. Prepare models of heating systems in lab.
  2. Conduction, convection, radiation.
IV. Which system will give the best service and the most comfort in our particular home, taking into consideration the number of rooms, and arrangements of rooms. Reasons.
V. Demonstration to class—with illustrations, drawings and models of systems.

Project B.—The Telegraph.

I. History of the Telegraph.
  1. Persons responsible for advance.
II. Collection of illustrations, models or charts of telegraphs, from earliest to present.
III. Home made set.
IV. Explanation of how the telegraph functions.
V. Code and the sending of messages.
VI. The place of the telegraph in modern life.

Project C.—Electricity in the Home.

I. What is electricity?

I. Understanding of electrical terms, or expressions.
II. How is it generated?
III. How does it get to our homes?
IV. List uses in the home.
1. Explain the electric light.
2. How does electricity heat the electric iron? Explain other devices.
V. How to use electricity or "don'ts in electricity."

The project method benefits pupils in the following ways:

1. Develops habit.
2. Helps them to do independent thinking.
3. Gives them satisfaction in accomplishment.
4. Develops habit of usage of scientific method.
5. Helps child to feel responsibility.

The project method besides being the outcome of strong initial interest on the part of the pupil helps him to get the information; teaches him how to use the scientific method of collecting facts and organizing them, gives him an experimental attitude in his science work and it is hoped toward other problems of life besides school work. Unadulterated interest and enthusiasm with the gradual development of initiative and responsibility on the part of the pupil is a fair judge of his progress.

The following statement is quoted from the book "Directing Study" written by Prof. H. L. Miller of the School of Education, University of Wisconsin: "The great teacher is the one able to stimulate curiosity, to foster interest in the search for knowledge, and to develop enthusiasm for the challenge of a problem."

SCIENCE TEACHERS OF PENNSYLVANIA TO ORGANIZE.

Science teachers of Pennsylvania are planning to form an effective state organization, at their meeting in Harrisburg in connection with the State teachers' convention, Wednesday, Dec. 29. Zone meetings of science teachers will be urged, with a central organization to assure unity of purpose. The organization will meet jointly with the science section of the State teachers' convention each year. The movement got under way at the Scranton convention last year, and has been endorsed by the Langley Association of Science Teachers, members of which are active in furthering it.

The Harrisburg meeting offers a strong appeal to science teachers of the state. Dr. Otis W. Caldwell will address the science section meeting Wednesday morning, Dec. 29, on "The Tendencies in Science Teaching," and will also speak at the general session of the convention that afternoon. Dr. J. A. Foberg, State Director of Mathematics and Science, will address the morning section meeting on, "Science in the Junior High School."

An inspection trip to a Harrisburg industry is being arranged. A science teachers' dinner at 6 o'clock, Wednesday evening, will be presided over by Dr. W. L. Eikenberry. Reservations for the dinner may be made at the morning section meeting.

RADIUM AND THE RAY-GENTOR.

By H. H. Barker,

Chief Physicist of the United States Radium Corporation.

"Radioactivity," to quote Frederic Soddy, Professor of Inorganic and Physical Chemistry of the University of Oxford, "is a new primary science owing allegiance neither to physics nor chemistry as these sciences were understood before its advent, etc."

In order to explain the phenomenon of radioactivity, Rutherford and Soddy advanced the theory which regards the atom of the radio-active element as suffering spontaneous disintegration, and giving rise to a series of radio-active substances which differ in chemical properties from the parent element. That is, the property of radio-activity is a phenomonon which occurs from within the atom, and as far as is known is not affected by any chemical or physical agencies which one can apply from without. To illustrate this property of intra-atomic disintegration, the uranium atom loses a helium atom carrying two positive units of electricity and results in the product Urnamium X1. This helium atom carrying two positive charges of electricity, known as the alpha ray, is expelled with a velocity of about one-tenth that of light. Uranium X1 undergoes a further atomic disintegration with the expulsion of a particle carrying a unit negative charge, known as the electron or beta ray, and producing a new element, Uranium X2. The beta rays or negative electrons are expelled with a velocity comparable to that of light and are quite analogous to the cathode rays. The third type of radiation which usually accompanies the beta rays are known as gamma rays and are quite analogous to the X-rays. They consist of ether vibrations of exceedingly short wave lengths.

Perhaps the most striking characteristic of the radio elements is their rate of decay or transmutation. The rate of decay for each element has been determined by actual observation rather than atomic weight determinations, due to the fact that radio-activity allows the study of very small quantities of these substances while atomic weight determinations would require relatively large amounts. Uranium, radium, radium emanation, ionium and thorium are the only members of the radio-active family that have been obtained in large enough quantities for atomic weight determinations.

For radio elements of long life such as radium with a "half period," by which we mean the time for one half of the original amount to disappear, of 1750 years, or uranium whose half decay period is about five thousand million years, more or less indirect methods must be used. The half decay period for these long lived substances may be ascertained by determining the number of alpha particles emitted from a known weight of a substance in a definite time. Since a gram atom of an element contains 6 x 10 to the 23rd power atoms, it is an easy matter to calculate the fraction of the number of atoms present decaying per second, each alpha ray representing one atom of radio-active matter undergoing transmutation.

In this connection it is perfectly correct to say that we are counting the number of atoms or molecules in a given substance with just as much accuracy as we count the inhabitants of a city. No census is correct to more than one or two parts in a thousand and this represents about the degree of accuracy with which we are able to actually count the number of atoms or alpha particles. An interesting simile was given in an address by Sir J. J. Thompson to show the great advantage of detecting electrified bodies over unelectrified bodies. Professor Strutt, by means of the spectroscope, was able to detect the neon in 1-20 cm^3 of air. Ramsay established that only 1-100,000 part of the air is neon, therefore the neon in 1-20 cm^3 would occupy 1-2,000,000 of cm^3 at S. T. P. In this small volume there are about ten million million molecules. The population of the earth is established at about fifteen hundred million, so that the smallest number of molecules of neon we can identify is about 7,000 times the population of the earth. In other words, if we had no better test for the existence of a man than we have for an unelectrified body of molecules, we would come to the conclusion that the earth is uninhabited. If the alpha particle had been uncharged, we would require more than a million million of them instead of one before we would have been able to detect them.

For the radio elements of comparatively short-perjod, such as radium emanation with a half period of 3.85 day, the electroscope may be readily used in determining the period of decay.

Now let us consider a little more in detail these various types of radiations and their peculiarities. The alpha rays in their passage through matter cause ionization and thus render air a

conductor of electricity and so discharge electroscopes, thus giving the basis for radium and radio-active measurements. They also affect photographic plates and produce phosphoresence in certain substances, for example, Sidot's Blend or phosphorescent zinc sulphide. This phosphorescent effect analyzed has been shown to consist of individual flashes of light.

Sir Wm. Crookes has devised an apparatus known as the spinthariscope for observing the scintillations due to radio-active matter. It consists of a trace of radium concentrated at a point and placed several mm. away from a zinc sulphide screen which is fixed at one end of a short tube, and viewed through a lens at the other end. One then sees hundreds of scintillations, each one of which is due to the bombardment of an alpha particle against the screen, thus indicating the transmutation of an atom of radium at the point. The rays are slightly deviated in a strong magnetic field at right angles to their path. The alpha rays from different radio-active substances have different velocities of expulsion and ionize the air for different distances. The rays are readily absorbed by thin sheets of paper or metal foil or a few centimeters of air due to the large mass of the particle and to its slow velocity. Upon stopping the alpha particle their extra energy is converted into heat. One gram of radium has been found to produce 135 calories of heat per hour, of which 124 calories are due to the alpha particle. From these figures it has been calculated that the disintegration of one gram of radium and its disintegration products develops at least 400,000 times as much heat as can be obtained by burning one gram of carbon, or a simple calculation will show that one pound of radium has inherent within its atoms the heat energy equivalent to 400,000 pounds or 200 tons of coal. One ounce of radium in its complete transformation to the end products will give off enough energy to lift 5,000,000 tons through a distance of thirty feet.

The beta type of radiations from radio-active substances are more penetrating than the alpha rays due to their relatively small mass, about 1-1700 the mass of the hydrogen atom, and the comparatively large velocity. Beta rays are more readily deflected by a magnetic field than the alpha rays, the ionization effect of the beta rays are about 1-100 that of the alpha rays over the same distance.

Gamma rays never appear independently of the beta rays and are probably produced by the beta rays just as the X-rays are

produced by the cathode rays. They are not deflected by a magnetic field. They are very penetrating as is shown by the fact that they will pass through one foot of iron, but their ionization effect is only about 1-10,000 that of the alpha rays.

The beta and gamma rays as well as the alpha rays are capable of producing phosphorescent effects on certain minerals, but not to the extent that the alpha rays are, while the gamma rays are even less intensive in their effect than either of the other two.

Radioactivity has thrown such a revealing searchlight of knowledge upon the structure of matter that even the most elementary instruction in physics and chemistry requires consideration of this most remarkable phenomenon. The wondrous facts of radioactivity are so elusive of real comprehension and appreciation that effective instruction must really rely upon the method of experimentation and demonstration.

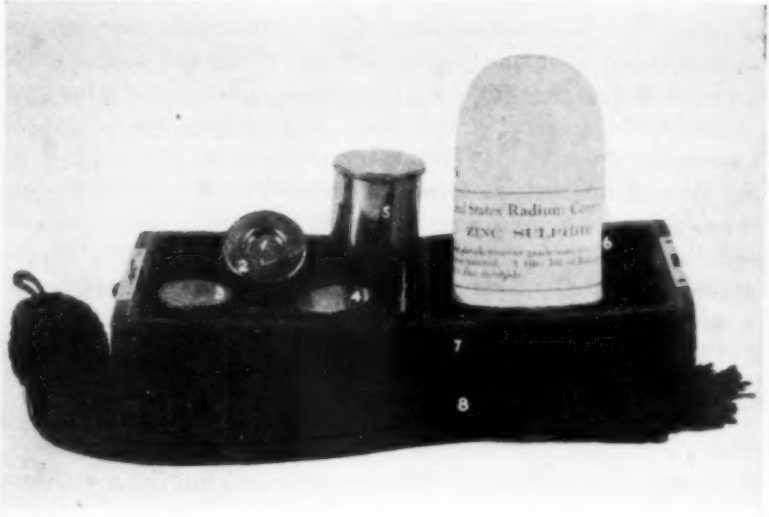
The Ray-Gentor is designed for the purpose of rendering a number of remarkable facts of radioactivity visible to the studen and thus creating that absrobing interest and true understanding which is impossible of creation by theory alone.

Such truths as the spontaneous, constant and long enduring giving off of tremendous energy by radium, becomes apparent by the use of the Ray-Gentor. In the dark and with but the most simple equipment, the individual ray can be shown to the student and the tremendous speed at which the rays are given off can be made understandable.

Description of Ray-Gentor.

Rutherford states that the alpha rays are completely absorbed by 0.0006 cm. of aluminum, the beta rays by 0.2 cm. of lead, and one half of the gamma radiation by 14 cm. of lead. By properly selecting a series of screens to place over a radium preparation it is readily seen that we may shut off, or absorb, first the alpha without appreciably stopping the beta and gamma, and then the alpha and beta without absorbing to any appreciable extent the gamma radiation. To obtain the effects of either the alpha or beta radiation exclusive of the other two is not a simple task, and requires appliances with which many laboratories are not equipped. However, to obtain the greater part of the alpha radiation together with the beta and gamma rays, the beta rays together with the gamma rays, and the gamma rays free from the other two is not so difficult, and the apparatus to be described was designed with that object in view. It may be stated that the effects of the beta and gamma radiation as com-

pared with the alpha radiation over the range of the alpha rays is small, about one per cent. The same is true for the effects of the gamma rays as compared with the beta rays over the range of the latter.



The main part of the Ray-Gentor, as shown, consists of a brass container filled with lead. There is a small depression in the lead in which the radium salt is deposited by evaporating to dryness a suspension of the sulphate or a solution of the chloride or bromides as the case may be. The film of radium in the shallow cavity is covered with a sheet of aluminum foil about 0.0002 cm. thick, held in place by a collar with both male and female threads. The thin aluminum foil serves to protect the radium from any mechanical losses, but is sufficiently thin to allow the greater part of the alpha radiation to pass through. There are two supplementary collars which fit onto the collar permanently attached to the main part of the applicator, one equipped with a screen or filter of sheet mica 0.006 cm. thick and the other with a sheet lead 0.2 cm. thick. It is thus possible by the use of the proper screen to obtain, (a) all three types of rays together, (b) the beta and gamma rays and (c) the gamma rays alone.

The utmost care should be exercised when handling the Ray-Gentor to avoid damaging the aluminum foil that serves to protect the radium. A brass cover filled with lead is supplied, which should be screwed onto the bottom section of the applicator when not in use.

Demonstration Experiments.

1. Ionization.

That the different rays ionize the air may be demonstrated by electrifying a silk tassel until all the strands repel one another and then bring the Ray-Gentor near to it.

(a) When the radium is screened by the aluminum foil only, it will be noted that the tassel is discharged almost immediately as the Ray-Gentor is brought near to it.

(b) Place the mica screen on the applicator thereby cutting off the alpha rays. As the applicator is brought near to the electrified tassel, it is noted that the tassel is not discharged nearly as rapidly as in (a), thereby demonstrating the comparative ionizing properties of the alpha and beta rays. By removing the Ray-Gentor some distance from the electrified tassel, it is still slowly discharged, demonstrating that beta rays have a much longer range than the alpha rays.

(c) Place the lead screen on the applicator and make the same test as in (b). The ionization effect of the gamma rays alone is demonstrated as very slight.

2. Photographic Plates.

All three types of rays affect the photographic plate. The alpha rays are much more intensive in their effect than either the beta or gamma and consequently require a much shorter exposure. The beta rays produce a rather fuzzy image, while the gamma rays produce a clear cut image. Various objects such as keys, etc., may be photographed by the various types or rays placing the object to be photographed adjacent to the negative and exposing to the Ray-Gentor. When producing photographs by means of the alpha rays it is necessary to unwrap the negative and place the object adjacent to it. Photographs may be made with the beta and gamma rays without unwrapping the negative.

3. Phosphorescent Zinc Sulphide.

A screen coated with phosphorescent zinc sulphide will glow extremely brightly in the dark when exposed to the alpha rays of the Ray-Gentor but responds poorly to the beta and gamma rays when the alpha rays are screened off. This experiment explains the nature of Undark Radium Luminous material which is used commercially to illuminate watch dials, electric lighting switches, house numbers, etc. The bright glow is caused by thousands of alpha particles impinging on the zinc sulphide crystals causing a brief spark of light.

4. Willemite.

The mineral Willemite fluoresces showing a beautiful greenish color when exposed to the Ray-Gentor.

5. Barium and Lithium Platinocyanide.

The lithium salt fluoresces with a brilliant pink color and the barium salt with a deep green light. These salts are especially suited for showing the action of the gamma rays, and in this respect, are superior to Willemite.

6. Range of Alpha Rays.

By carefully bringing a zinc sulphide screen up to the Ray-Gentor and noting when the screen begins to glow brilliantly, the range of the alpha particles may be determined.

7. Electromagnet.

Inasmuch as the alpha rays are positively charged particles, the beta rays, electrons (negative charge), and the gamma rays, ether vibrations only, a powerful electromagnet may be used to separate the three types; the alpha being deviated in one direction, the beta in the opposite direction, while the gamma rays remain unchanged in their direction. This phenomenon may be shown by placing the Ray-Gentor between the poles of the electromagnet, and using a suitable screen or photographic method to locate the paths of the different types of rays.

8. Electroscopes.

With electroscopes of the alpha, beta or gamma ray type, many instructive demonstrations may be made, such as the methods of measuring radium, range of the rays, co-efficient of absorption for different substances, etc.

The above are some of the more standard demonstrations possible with the Ray-Gentor. Its value in experimentation and research makes the instrument truly indispensable.

THE LANGLEY ASSOCIATION OF SCIENCE TEACHERS PROPOSES A STATEWIDE ORGANIZATION.

At the annual meeting of the Langley Association of Science Teachers recently held at Pittsburgh, Pa., action was taken looking toward the formation of a more perfect union of the science teachers of the state. Leaders in the Pennsylvania State Education Association have long felt the need of an organized science section to meet in December of each year, at which time representatives will gather from local branches with headquarters in the several convention districts of the state. The Langley Association has gladly consented to assist in this important movement which will be started at the State Convention of the P. S. E. A., Harrisburg, Dec. 28-30.

The fall meeting of the Langley Association was held in Pittsburgh, Oct. 22 and 23. The Nature Study Club met in joint banquet Friday

evening. The addresses of the occasion was given by Dr. Heber D. Curtis, Director of Allegheny Observatory, "The Recent Total Eclipse of the Sun." The second session of the association was held Saturday morning in the Schenley High School. The programs were as follows:

FRIDAY, OCTOBER 22.

4:00 P. M.—Tour through the Bureau of Mines.
5:30 P. M.—Reception in the Auditorium of Bureau of Mines.
6:15 P. M.—Dinner. Bureau of Mines banquet room.
7:30 P. M.—Annual election of officers.
8:15 P. M.—Illustrated Address, "The Recent Total Eclipse of the Sun," by Dr. Heber D. Curtis, Director Allegheny Observatory.

SATURDAY, OCTOBER 23, SCHENLEY HIGH SCHOOL, PITTSBURGH.

9:00 A. M.—Demonstration Lesson, "The First Day in Chemistry," Charles A. Gorgas, Peabody H. S.
9:45 A. M.—Address, "Carbon Monoxide Poisoning in the Home and on the Highway," by Dr. Williams P. Yant, Associate Chemist, Bureau of Mines.
10:15 A. M.—Address, "Research at Low Temperatures," (with demonstrations), by Dr. C. W. Kanolt, Physcist, Bureau of Mines.
11:00 A. M.—Adjournment to the auditorium for general meeting of the Western Convention District of the P. S. E. A.

Anyone desiring to join this association or inquire concerning its publication, "The Langley Science Bulletin," should communicate with the secretary, Frank W. Murphy, Oliver High School, Pittsburgh, Pa.

AVERAGE LIFE NOW 58 YEARS.

The present average duration of life in the United States is 58 years. Prof. Irving Fisher of Yale gave a schedule of how the duration of life should increase in the years to come assuming that a hundred-year average duration is the attainable limit.

In 1930, the average length of life will be 61; in 1940, 65; 1950, 69; 1960, 72; 1970, 75; 1890, 78; 1990, 80; 2000, 82. In the distant time of 2100 nearly everyone should live until 94 years of age.

Prof. Fisher pointed out that increases in length of life were being made at an amazing rate at the present time. The pace for the quarter century just past was 40 years increase per century, whereas it was only 4 years per century in the seventeenth and eighteenth centuries.

Prof. Fisher presented what he declared to be: "The most sensational conclusion which science has ever reached." It is that life cells and many tissues of man are potentially immortal in the pure physical sense. There will be a time, perhaps, when men will live, if not forever, at least much longer than the century mark which is now practically the limit of the human life span.

Prof. Woodruff of Yale, he recalled, found that no natural death occurred in 8,500 generations of a minute organism, paramecium, a period of time equal to 250,000 years of human life. Dr. Alexis Carrel of the Rockefeller Institute for Medical Research has kept a chicken heart growing and alive for over fifteen years, an age that no chicken can attain. Prof. Thomas H. Morgan of Columbia found that 1-250 part of a worm will regenerate and become younger than the original worm. The time will come perhaps, Dr. Fisher said, when the human being will have an indefinite life span, when his defective and worn-out parts can be replaced and renewed like those of a watch.—*Science Service.*

A STUDY OF THE VOCABULARY OF SCIENTIFIC ARTICLES APPEARING IN DAILY NEWSPAPERS.[1]

By Francis D. Curtis,
University of Michigan.

Introduction

In a previous study[2] the author made a series of analyses of the six hundred thirty articles of miscellaneous scientific content published in two weeks' consecutive issues of six American newspapers representing widely different parts of the country and types of cities: the New York *World*, New York *Times*, *Christian Science Monitor*, Houston *Post*, Bristol (Va.-Tenn.) *Herald Courier*, and Portland *Oregonian*. The last of these analyses included a listing of all the *different* scientific terms found in the articles, and a comparison of these terms with Thorndike's "Ten Thousand Words"[3] to determine the percentage of these different terms which are in each respective thousand of the most common English words as listed in *The Teacher's Word Book*.

This analysis revealed the fact that only 35.1 per cent of the different miscellaneous scientific terms which were found in these articles appeared also in *The Teacher's Word Book* and that these 35.1 per cent were distributed fairly equally among the respective thousands, the range being between 4.5 per cent for the first thousand and 2.1 per cent for the sixth, with an average of 3.5 per cent for all ten of the thousands in the Thorndike list.

The investigator concluded from these facts that "the addition to a child's reading vocabulary of each thousand of the most frequently occurring words does not add greatly to the equipment for an intelligent reading of science in the public press, and that vocabulary building based upon *The Teacher's Word Book* does not in itself promise to provide adequately for the needs of pupils in science"; that the range of scientific vocabulary found in the public press emphasizes the need for extensive training in science as a foundation for an intelligent reading of the newspapers.

Problem

This investigation represents an attempt to secure data

[1] Reprinted from *School and Society*.
[2] Francis D. Curtis, *Some Values derived from Extensive Reading of General Science* (New York Teachers' College, 1924), pp. 10-27 and Appendices A and B.
[3] Edward L. Thorndike, *The Teacher's Word Book* (New York: Teachers' College, 1921).

relative to the vocabulary used in scientific articles appearing in the daily press: (1) what percentage of the total vocabulary are common English words; (2) what percentage of the total vocabulary are scientific terms; and (3) what percentage of the uncommon words are scientific terms. A word is here considered to be a common word if it appears in *The Teacher's Word Book;* a word is here considered to be an uncommon word if it does not appear in *The Teacher's Word Book.*

METHOD

The materials used in this investigation were the same six hundred thirty articles which were used in the previous analyses. This selection of articles included all having scientific content which appeared in the issues of the six newspapers studied, except the weather forecasts and the "death notices." No advertisements were included.

The following directions guided the making of the word counts:[4]

(1) Take the articles in turn and count all the words, including *a* and *the.* Count initials and abbreviations as words and count compound words as two words. Consider a *number* to be composed of the words which would be required to express the number were it spelled out; thus, you would count 216 (two hundred sixteen) as three words, and 1,049.2 (one thousand forty-nine and two tenths) as seven words.

(2) Recount the words in each article until you check within *three* words of the total secured by a previous count; write this number at the top of the article and mark it "O. K." to indicate that you have checked the count and have found it to be accurate within *three* words.

(3) Read carefully in *The Teacher's Word Book* the "Instructions for using The Teacher's Word Book," especially the last two pages of these instructions. Draw a black line under every word, including those in headings and in legends under illustrations, which does not appear in *The Teacher's Word Book.* Do not underline people's names or initials, even though they do not appear in the Word Book, since these do not add to the reading difficulty; but underline all geographical

[4]The author wishes to make grateful acknowledgment of the assistance of the following graduate students of the University of Michigan: Gayla A. Gamble, Ruth Crossman, Mary L. Scriver, LeRoy A. Pratt, Grace E. Bagby, Vera Haven, Cora A. Smith, Myrtle B. Wilcox, Katherine E. Motherway, Lola A. Lambert, Carolyn K. Hartwell, Linda B. Varty, Otto N. Norwalk, William F. Wilcox, Gertrude H. Vanderberg, Victor L. Whittemore, Homer A. Clark, Lofton V. Burge, Elmer A. Shumar, Aurie J. Dean, Thomas J. Gwynn, Floyd I. Leib, Byron J. Rivett, J. Walter Cowin, Frederic A. Scott, and George C. Kapnick.

names which do not appear in the Word Book. Underline a number printed in figures only provided one of the words of which it would be composed if it were spelled out, does not appear in the Word Book; thus, you would underline 2,000,000,-002, because *billion* does not appear in the Word Book, but you would not underline 2,000,002, because both *two* and *million* appear in the Word Book.

(4) Count all the underlined words and recount them until you are sure that the total for each article is correct. Write this number at the top of the article beside the previous total; underline it, and write "O. K." beside it to indicate that you have checked the underlining and the count and have found both to be correct.

There were no subjective factors in the investigation up to this point. In order to insure against errors in marking or in counting, at least two different graduate students made or checked the underlinings and the counts for each article.

The author then reread the articles for the purpose of locating all the scientific terms appearing in them. He underlined these in red pencil.

The decision regarding whether a given word or group of words constitutes a scientific term is more or less an arbitrary one, depending upon the connotation of the word or group of words in the particular passage in which it is found. For example, "acid" is not a scientific term in "an acid smile," while it is in "an acid solution"; the word, "sucker," as applied to a duped investor is not a scientific term, but it is a scientific term when used to designate a species of fish.

To minimize the subjectiveness of the judgment with respect to whether or not a certain word were a scientific term, one or more readers beside the author gave each article a critical reading for scientific terms. No word was finally counted as a scientific term unless there was unanimous agreement between the author and the other reader or readers that that particular word possessed scientific connotation in the sense in which it was used. While this procedure may have resulted in omitting from the final total of scientific terms an occasional word which a majority of opinions of a number of judges might have included, it was deemed likely to eliminate the "borderline cases" and to leave in the final count few or no words of doubtful scientific connotation.

The total number of scientific terms appearing in each article, when proved to be accurate by a recount, was written in red beside the two other totals at the top of each article, and was marked "O. K."

The articles appearing in full-page "Radio Sections" in three issues of the Portland *Sunday Oregonian* were treated as above, but the findings are here considered separately, because such articles are intended for the specialist and the expert rather than for the general reader, and because the science of radio is too new to have its complex and rapidly increasing terminology represented in the Thorndike list. The importance of the "Radio Section" to a constantly increasing number of readers of newspapers, however, entitles this material to serious consideration in this study.

Findings.

(1) There is no apparent relation between size of circulation or national importance of these six newspapers and the percentage of scientific terms which appear in the miscellaneous scientific articles of the issues studied. The Bristol *Herald-Courier* has a larger percentage of scientific terms than the New York *World*, while the Houston *Post* and the Portland *Oregonian*, representing cities of approximately the same class, are respectively lowest and highest with 2.5 per cent and 6.1 per cent.

Table I.

Word-Counts of the Scientific Articles Appearing in Two Weeks' Consecutive Issue of Six Daily Newspapers

Name of Newspaper	Number of Words	Number of Scientific Terms	Number of Uncommon Words	Number of Scientific Terms in the Uncommon Words
New York *World*	59,880	2,447	1,830	711
New York *Times*	59,826	2,856	2,142	773
Christian Science Monitor	26,814	836	1,032	297
Houston *Post*	34,387	851	1,028	240
Bristol (Va.-Tenn.) *Herald-Courier*	24,011	1,135	853	267
Portland *Oregonian* (Miscellaneous)	48,428	2,937	2,134	811
Portland *Oregonian* (Radio Section)	18,317	1,740	631	478
Total	271,663	12,802	9,650	3,577

(2) The percentage of "uncommon" words found in the miscellaneous scientific articles is small, being on the average

only 3.6 per cent. This statement is equivalent to saying that out of approximately every twenty-eight of the words composing these scientific articles, all but one are included in *The Teacher's Word Book*.

(3) The respective percentages of "uncommon" words appearing in these miscellaneous scientific articles are approximately equal. The range is from 3.0 per cent for the Houston *Post* to 4.4 per cent for the Portland *Oregonian*, while the average for all six newspapers is 3.6 per cent. If this meager sampling can be considered representative of American newspapers, then there is a surprising uniformity in the proportion of common words used in scientific articles in "small-town" and metropolitan dailies; a study of the materials indicates, moreover, that this fact is only partly accounted for by syndicated materials.

TABLE II

Percentage Based Upon the Word Counts of the Scientific Articles Appearing in Two Weeks' Consecutive Issues of Six Daily Newspapers.

Name of Newspaper	Percentage of Scientific Terms in Total Vocabulary	Percentage of Uncommon Words in Total Vocabulary	Percentage of Scientific Terms in Uncommon Words
New York *World*	4.1	3.1	38.9
New York *Times*	4.8	3.6	36.1
Christian Science Monitor	3.1	3.8	28.8
Houston *Post*	2.5	3.0	23.3
Bristol (Va.-Tenn.) *Herald Courier*	4.7	3.5	31.3
Portland *Oregonian* (Miscellaneous)	6.1	4.4	38.0
Portland *Oregonian* (Radio Section)	9.5	3.4	75.8
Average [5]	4.2	3.6	32.7

(4) There is a considerable degree of uniformity in the respective percentages of scientific terms found in the "uncommon" words composing these miscellaneous scientific articles. The smallest percentage is 23.3 per cent for the Houston *Post*, and the highest, 38.5 per cent for the New York *World*, while the average percentage is 32.7 per cent.

(5) As shown by the average for the last column of Table II, slightly more than two thirds of the scientific terms appearing in these miscellaneous scientific articles appear also in the

[5] The percentages for the Portland *Oregonian* Radio Section are not included in these averages.

Thorndike list. It will be seen in Table II, moreover, that even in the "Radio Sections," only 3.4 per cent of the words used fall outside of the Thorndike list, despite the highly technical nature of these articles, as indicated by the fact that 9.5 per cent of the words composing these sections are scientific terms, and by the further fact that 75.8 per cent of the "uncommon" words appearing in these articles are scientific terms.

Implications

If we accept as a worthy and practicable aim of our schools the training of pupils for the worthy use of leisure, and if we further grant that, since the reading of newspapers is a leisure pursuit of practically all literate adults, the training of boys and girls to read intelligently the public press is a worthy objective of our schools, then the training of our pupils to read with understanding and profit the scientific articles appearing in newspapers becomes a legitimate part of the broader culture.

Finding 5 above would seem to indicate that spelling drill and word-building based upon the Thorndike list are sensible first-steps toward training pupils to read science appearing in newspapers. But unless pupils are given specific drill and training in the scientific connotations of many of these common words, much of the science appearing in the newspapers can have little meaning for them.

The following paragraphs quoted from the articles used in this study illustrate this point:

"The condensed mercury runs back by gravity into the mercury boiler. Thus the mercury vapor acts as a heat *conveyor* and at the same time delivers energy to the mercury *turbine*. This affords a means by which the temperature range of operation is more than doubled as compared with ordinary steam processes and the efficiency consequently greatly increases. Means are also provided by which the flue gases are brought to temperatures equivalent to those used in steam processes by being carried through a steam *superheater* and a feed water heater."—New York *World*, Dec. 7, 1923.

"The flexible leads from the plugs on a honey-comb coil mounting have a habit of breaking when least expected. The trouble makes itself known by a loud cracking noise in the receivers."—Portland *Oregonian*, Nov. 18, 1923.

"Not particularly. You are bound to hear a *click* in the phones on the instant the battery is connected into the circuit.

Whenever an electrical circuit is opened or closed quickly, magnetic lines of force are set up around the circuit which the telephone receivers register. It is quite likely that you did not notice the *click* before you took your receiver apart. Connect up the battery and see if you hear any radio stations. If you hear nothing, then you must have a loose connection, somewhere or a short-circuit."—Portland *Oregonian*, Nov. 25, 1923.

Only the italicized words in these paragraphs are "uncommon" in the sense that they do not appear in the Thorndike list. Yet it is obvious that the significance of these passages would be grasped only by that occasional reader who possesses a knowledge of the *scientific* connotations of many common words appearing in these paragraphs.

This study, therefore, gives added weight to a conclusion from the previous study of this same material:

If pupils are to receive in the schools adequate training for an intelligent reading of the science appearing in the public press, further studies should be made aiming to ascertain the scientific terms which appear most frequently in the daily press. The pupils must then be given specific training and drill, affording them a familiarity with and an understanding of the *scientific connotations* of these more common scientific words, both those which are and those which are not included in lists of common English words.

It seems probable that such a list of scientific words objectively selected as a basis for training in reading *newspaper* science will be found to contain much of the special scientific vocabulary needed for an understanding of magazine science.

THE VELOCITY OF A RIFLE BULLET.

By N. F. Smith,

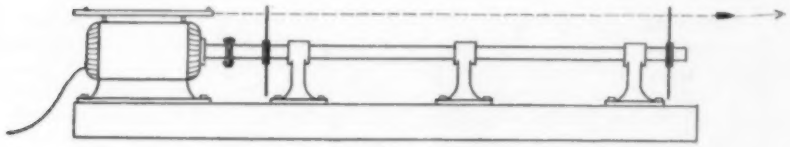
The Military College of South Carolina.

The determination of the velocity of a rifle-bullet by means of the ballistic pendulum has long held a place in laboratory courses in Physics. The experiment is a most valuable one because of the number and importance of the physical principles involved. The interest of the student is far greater if he uses a real rifle than if any "pop-gun" device is employed. The experiment is not satisfactory, however, in one respect,—no check method is ordinarily available by which the student can tell whether his result is right or wrong.

An excellent form of this experiment was described by Klopsteg in a recent number of this magazine, ("The Ballistic Pendulum," School Science and Math. Vol. XXV, p. 694, Oct. '25) but the check method there described is, of course, impossible if a rifle is employed.

The Ordnance Department of the United States Government employs a modified form of the Boulengé chronograph. This instrument is designed to measure the time which elapses between the successive ruptures of two electric circuits. In front of the gun are placed two vertical screens, fifty feet or more apart. On each screen is stretched a continuous wire which passes back and forth to form a grid, the spacing of which depends upon the size of the projectile. Each wire forms a part of one of the two circuits. In passing through the screens, the projectile breaks, successively, both the circuits connected with the instrument. The chronograph records the time between the interruption of the two circuits. From this, and the distance between the screens, the velocity of the projectile is known.

This apparatus is too complicated and too costly for laboratory use, and the following simple and direct method has been used in the writer's laboratory with excellent results.



A horizontal shaft of 5/8″ steel, about eight feet long, is directly connected through a universal coupling with the shaft of a one-quarter horse-power induction motor. The shaft and motor are mounted together on a two-inch plank, as shown in the figure. The shaft carries, at each end, a light card-board disc about 15 inches in diameter, the one farthest from the motor having a graduated circle engraved upon it. The rifle is clamped in a position parallel to the shaft and directly above it, so that the bullet will pierce each disc near the circumference. A suitable barricade must, of course, be provided to stop the bullet. If the rifle is fired while the shaft is rotating, the hole in the second disc will lag behind the hole in the first by an angle proportional to the rate of rotation of the shaft, and to the time of

flight of the bullet between the discs. To measure this angle, the motor is stopped and the shaft rotated till the hole in the first disc is in line with the bore of the rifle, as determined by sighting through the open breech. The point where the line of sight meets the second disc is then read on the graduated circle.

The speed of the motor may be determined directly with stop-watch and revolution counter, or more accurately, by the "method of slip," described in any laboratory book which deals with the induction motor.

Using a .22 caliber army rifle, and a motor having a synchronous speed of 1200 revolutions per minute, the angle of lag is about sixty degrees. This angle can be measured to an accuracy of 1-2 degree. The velocity determined is about 1000 feet per second. The results obtained by different students differ by two or three per cent, and the results obtained by this method differ from those obtained by the ballistic pendulum by about the same amount. This probably represents, not experimental error, but actual differences in the velocities of different bullets.

SOME COMMENTS ON THE NATIONAL COUNCIL OF MATHEMATICS TEACHERS' YEARBOOK.

By H. C. Wright,

Deerfield-Shields Township High School, Highland Park, Ill.

Following the February meeting of the Council of Mathematics Teachers in Washington, their first yearbook was issued, and has no doubt found its way into the hands of many readers. It is to attract the attention of mathematics teachers, especially the younger ones, that the writer of these comments has undertaken this brief summary of the contents of the yearbook.

The general theme of the yearbook is a survey of progress in the past twenty-five years in the teaching of mathematics in the United States. To cover the era, there are nine papers, eight of which were prepared for the volume and one of which is a reprint of the address of Professor E. H. Moore before the American Mathematical Society in 1902. Professor David Eugene Smith contributes a survey of the progress of mathematics in our high schools in the last twenty-five years. Professor Raleigh Schorling, of the University of Michigan, makes suggestions for the solution of an important problem that has arisen in the last quarter of a century: i.e., the problem of improving the scholarship of the high school pupil. Professor William D. Reeve, Teachers College, Columbia University, writes on the improvement of tests in mathematics. Professor Frank Clapp, of the University of Wisconsin, reports some recent investigations in arithmetic. Mr. William Betz, of Washington Junior High School, Rochester, New York, discusses the development of mathematics in the junior high school. Professor Herbert E. Slaught, of the University of Chicago, writes interestingly on mathematics and the public. Miss Marie Gugle and others, of the Columbus Schools, Columbus, Ohio, tell of the recreational values achieved through mathematics

clubs in high schools. And to conclude the list of valuable contents, Mr. Edwin W. Schreiber, of Maywood, Illinois, gives a list of mathematics books published in recent years for our schools and for our teachers.

One who has taught mathematics in the public and private high schools for the last twenty-five years—the period covered by this yearbook—finds in it many of the topics he has heard discussed and the projects he has seen undertaken in the classroom. The nine papers of the volume are the work of some of the most widely known and successful teachers of mathematics in both the secondary and collegiate fields of instruction. These teachers have had their objectives, some of which they have accomplished, and some of which they are now attempting to realize. Because of these circumstances, a reader has an excellent opportunity to acquaint himself with much worth while material.

Even a causal perusal of the volume (and two hundred and ten pages in fair size type is easily browsed through), has its reward. An instance in point is found in Professor Moore's "On the Foundations of Mathematics," in which after a few pages he passes to the discussion of the elementary field and particularly to the high school materials and methods. After reviewing the practices then current and undergoing changes in the British schools, he makes an appealing argument for the use of the laboratory method in teaching mathematics in the secondary schools of the United States. Much of the technique now coming into vogue with the program makers and the curriculum builders is suggested in this presidential address. Why not read it, then, and either refresh one's memory or obtain new ideas for improving the classroom work? A second item is Professor Schorling's statement that the real passing mark of our American secondary schools at the present time is somewhere between 40 per cent and 50 per cent. He has lead up to this conclusion by a study of mastery in arithmetic and in algebra. And it would be hard to gainsay him. But he does not bring us to his somewhat startling statement and leave us without recourse. He has a job for the mathematics teacher that is worthy of his best mettle. His suggestions for improving the scholarship of the young pupils are of interest.

One of his proposals for the improvement of the pupils' scholarship is an extensive use of the psychology of drill. He has a most interesting and detailed discussion of drill in algebra. He is aware of much of the experimental study that has been made on drill technique and the results of different time periods and different materials. The writer of this review has not seen as comprehensive a discussion of drill as it may be carried on in the high school classroom. Much of this discussion is most pertinent to our class room needs.

The "General Survey of the Progress of Mathematics in Our High Schools for the Last Twenty-Five Years," by Professor David Eugene Smith gives the changes in arithmetic, algebra, geometry, and the uses being made of numerical trigonometry. The author reviews the influence of three important mathematical bodies; the International Commission on the Teaching of Mathematics, the National Committee on Mathematical Requirements, and the College Entrance Examination Board. The influence of these groups, together with the rise of the junior high schools, the improvement in textbooks, and the general spirit of the times, are the chief causes of the progress. In fact, Professor Smith finds the mathematical field to have advanced as markedly as any of the secondary fields of instruction. He gives an optimistic outlook for the subject in the schools.

We have had a number of studies of tests used in the elementary school, but few of tests applicable to the secondary school. Professor Reeve has

had considerable experience in the endeavor to formulate tests in the mathametical field that might give diagnostic results which would improve the instruction. In his yearbook article, he proposes making the tests of a nature that will give the pupil a chance to keep his test record and to try for improvement, perhaps as a golf player does. Mr. Reeve puts the emphasis on the teacher's tests being of the right character, rather than on the use of the so-called standard tests.

"The Development of Mathematics in the Junior High School," by Mr. William Betz of Rochester, N. Y., brings to notice a considerable number of the more important articles that have dealt with the mathematical side of the junior high school. His experience in this division of the high school has been extensive and his references are most valuable. He has discussed not only the subject matter but also the preparation of the teacher and other phases of the situation. Some of these are: the struggle between stratified and unified mathematics; ability grouping; use of standardized tests; the arithmetic situation; and the case of intutive geometry.

In Professor Slaught's short paper, we find one of his typical efforts to humanize mathematics. And to this end, he points out several important and most useful applications of the mathematical methods to the purposes of war, of industry, and of scientific investigations.

Perhaps the high school teachers fail to realize the extent to which the arithmetical difficulties prevail in the elementary schools. If so, Professor Clapp's studies will have peculiar interest to us in the high school. He reports several complete investigations and several now under way.

To the women was given the opportunity to make some fine suggestions for the recreational side of the secondary pupil's mathematics. Mathematical clubs have long engaged the attention of Miss Gugle and her aids in Columbus. Their report is a most concrete and valuable one. It contains specimen programs that are rich in suggestion of the kind of thing that may interest the young pupil in mathematics. The Philadelphia "Enquirer" in its Sunday funny sheet last summer ran an algebraic problem in story form and illustrated by a good cartoonist. Any one of these would make an entertaining feature in a mathematics club program.

Though Mr. Schreiber's book list comes at the end of the volume, it might well be the first thing the reader turns to, for some of us read our magazines from the back rather than from the front. In looking over his list one wonders why there has been a number of reprints of such titles as Jones' "Mathematical Wrinkles" and Young's "Teaching of Mathe-matics in the Elementary and Secondary School." It must indicate their lasting value. These and other titles keep Mr. Schreiber's list from being one of wholly recent titles. However, this makes it no less valuable.

In Professor Moore's address, there is a suggestion to use colored chalk. One experiment is to designate the angles of similar polygons by arrows of the same shade of color, and talk about these angles as the "red", or the "orange" angles instead of angle "A," or angle "BAC." It is quite possible that the pupils can follow the colors more readily than they do the literal notation. Another suggestion in the address is for more use of cross-section paper. Many teachers have certain algebraic equations solved graphically, but seldom have the pupils try to solve the verbal problems, such as the motion-type problem, or some of the problems involving the physics formulas. Making the mathematics work more spectacular would seem practicable, and perhaps, also more interesting to the young student.

While Professor Reeve does not mention the fact in his paper, he is a co-author of a very comprehensive and unique booklet of tests for use in the first year algebra classes. This is a book for the individual pupil to own and to keep as a record of his test performances. A reading of the Yearbook paper in connection with this booklet of tests would make the points in the article very concrete. With the test in his possession, the pupil could practice on the material for greater proficiency and by means of a similar test could show whether he had improved. Then with all his year's tests in a well bound volume he can see just what kind of a showing he made. Some of my readers will recall their old spelling tablets in which the teacher recorded the "100" and other grades put on the papers from day to day. It was a durable record of one's achievements.

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,

Illinois State Normal University, Normal, Ill.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.

The *Editor* desires that more solutions of the High School Problems should be sent in. It ought to be an inspiration to the High School Pupils to see how the Master Teacher works in the same field of study. Along with the Solutions by the High School Pupils will be published the Solutions by the Master Teacher. In many cases the proposed problems are of a very elementary nature, while others may seem beyond the High School Pupil.

Contributors to this department should give their street address when sending in problems and solutions. Many times the *Editor* desires to write to the contributors. The *Editor* welcomes suggestions relative to improvement of this department.

Late Solution.

921. *Proposed by R. T. McGregor, Elk Grove, Cal.*

The square on the third diagonal of a quadrilateral inscribed in a circle is equal to the sum of the squares of the tangents to the circle from its extremities.

Solved by J. T. Crawford, Toronto, Canada.

(See figure on next page.)

Describe a circle through EFC to cut AC at M. Then the quadrilateral ADFM is concyclic, as the angles at D and M are easily proved to be supplementary.

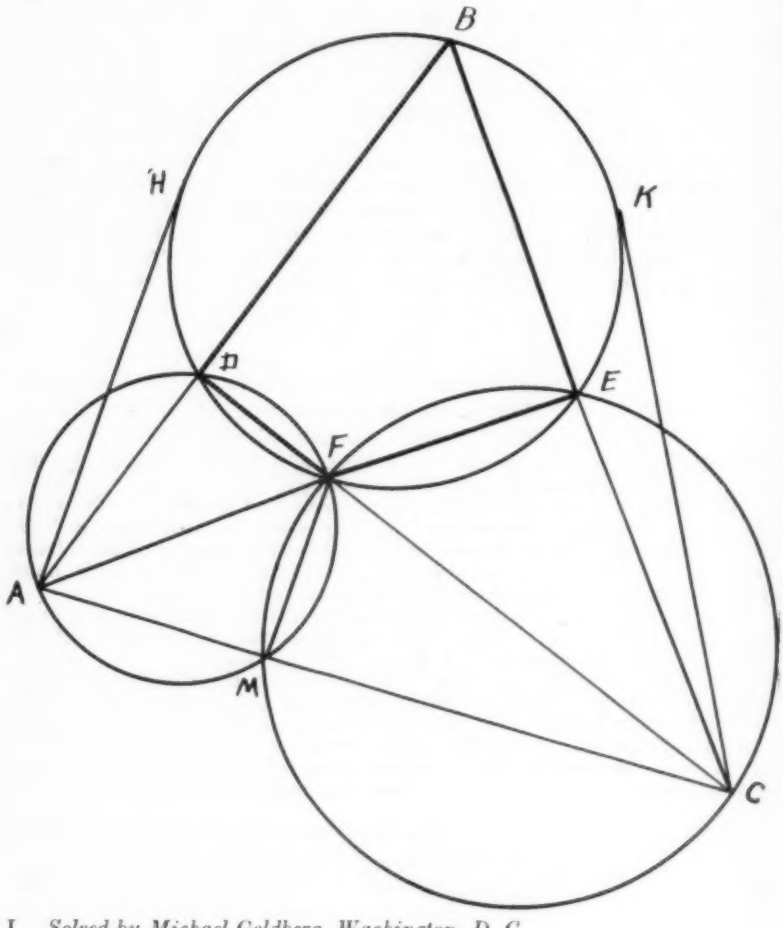
$$(AH)^2 = AF \cdot AE = AMC.$$
$$(CK)^2 = CF \cdot CD = CMA \cdot AC.$$
$$(AH)^2 + (CK)^2 = (AC) \cdot (AM + C \cdot M) = (AC)^2$$

SOLUTIONS OF PROBLEMS.

931. *Proposed by R. T. McGregor, Elk Grove, Cal.*

$\sin A + \cos A + \tan A + \cot A + \sec A + \operatorname{cosec} A = 1.$

What is the angle A satisfying this condition?



I. *Solved by Michael Goldberg, Washington, D. C.*

If all the functions are expressed in terms of the sine (s) and substituted in the given equation, after rationalizing, we get

$$s^6-s^5-s^4-s^3-s^2-3s=0. \qquad (1)$$

Removing the extraneous roots $s=0$, and $s=-1$, the equation (1) reduces to

$$s^4-2s^3+s^2-2s+3=0. \qquad (2)$$

In equation (2) there are no permanences of signs, hence no negative roots. There are no real positive roots in the interval $0<s<1$. Hence no real angle will satisfy the given equation.

II. *Solved by Fred A. Lewis, University, Ala.*

Expressing the functions in terms of sinA and cosA, the equation reduces to

$$\sin A+\cos A+\frac{1+\sin A+\cos A}{\sin A\cos A}=1.$$

Setting $\sin A+\cos A=X$, and $\sin A\cos A=Y$, we have $XY-Y+X+1=0$. Making use of the relation $X^2-2Y=1$, we get $X^2-2X+3=0$. The values of X for this equation are imaginary, and there are no real angles which satisfy the given equation. *Editor.* The graphs of the two equations shows that there are no real positive values of X.

Also solved by *Walter R. Warne, University of Minn.; T. E. N. Eaton, Redlands, Cal.;* and by *P. H. Nygaard, Spokane, Wash.*

932. *Proposed by Nathan Altshiller-Court, Norman, Okla.*

The perpendiculars from the orthocenter of a triangle upon the medians meet the corresponding sides of the triangle in three collinear points. The line through the points is perpendicular to the *Euler line* of the triangle.

Solved by George Sergent, Tampico, Mexico.

Solution I. Let ABC be the triangle, AA′, BB′, CC′ the medians; H the orthocenter, and O the center of the circumcircle; O_1, O_2, O_3 the centers of the circumcircles of the triangles BHC, CHA, and AHB; N the center of the nine-point circle; P, Q, R the points where the perpendiculars HK_1, HK_2, HK_3, to the medians, meet the sides a, b, c; M_1, M_2, M_3 the centers of the cyclic quadrilaterals $A'DHK_1$, $B'EHK_2$, $C'FHK_3$.

We have $PK_1 \cdot PH = PA' \cdot PD$. The nine-point circle, N, bisects AH, BH, CH, in L_1, L_2, L_3.

$$AL_1 = L_1H = OA' = O_1A'.$$

In the parallelogram L_1HO_1A', the diagonal L_1O_1 bisects HA′ in M, and being parallel to AA′, it is the perpendicular bisector of HK_1. K_1 is the symmetric of H with respect to L_1O_1, and lies on the circumcircle of the triangle BHC. We have then

$$PK_1 \cdot PH = PA' \cdot PD = PC \cdot PB,$$

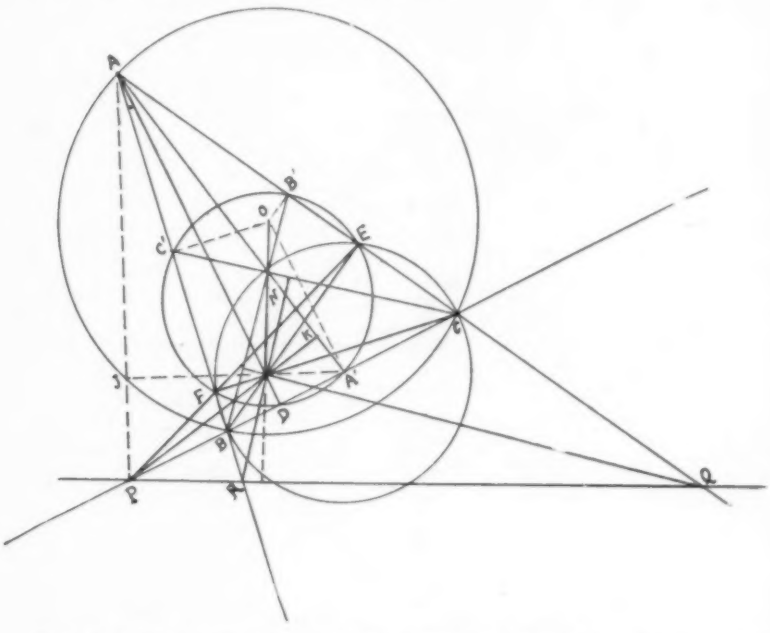
which shows that P is the radical center of the circles M_1, N, O_1, and O. It lies also on the radical axis of the circles O and N.

By considering the cyclic quadrilaterals $B'EHK_2$, $C'FHK_3$, it can be shown that

$$QK_2 \cdot QH = QB' \cdot QE = QA \cdot QC,$$
$$RK_3 \cdot RH = RC' \cdot RF = RA \cdot RB.$$

Hence Q and R are, respectively, the radical centers of the groups of circles M_2, N, O_2, and O, and M_3, N, O_3, and O. Consequently P, Q, and R and on the radical axis of the circles O and N, which is perpendicular to their line of centers, ON, the *Euler line* of the triangle.

Solution II. This proof is based on the following theorem: *In a quadrilateral inscribed in a circle, the point of intersection of the diagonals, and the points of intersection of the opposite sides form a triangle in which each vertex is the pole of the opposite side.*



ABC is the given triangle; AD, BE, CF, the altitudes, meeting in H; AA′, BB′, CC′, the medians. The quadrilateral BFEC, whose diagonals are two altitudes of the triangle, is inscribed in the circle, center at A′, and of radius $(a/2)$.

Let the opposite sides EF and CB meet in P, and consider the triangle PHA. By the theorem quoted above,

PH is the polar of A,
AH is the polar of P,
PA is the polar of H,

with respect to the circle A′. This means that PH is $\perp$A′A, AH is $\perp$A′P, and AP is $\perp$A′H. Also

$$A'A \cdot A'K = A'P \cdot A'D = A'J \cdot A'H = (a/2)^2.$$

The $\perp$HK from H to the median AA′ coincides with the polar, PH, of the vertex A, with respect to the circle A′, and meets the side a in a point P, intersection of EF and CB.

PFE and PBC are secants of the same circle A′. But PFE is also a secant of the nine-point circle, N; PBC is a secant of the circumcircle, O.

Since, by the circle A′, we have $PE \cdot PF = PC \cdot PB$, it follows that P, having the same power with respect to the circles A′ and O, N, is their radical center, and that it lies on the radical axis of the circles O and N.

Similarly, by considering the cyclic quadrilateral CDFA and its polar triangle QHB, the cyclic quadrilateral AEDB and its polar triangle RHC, it can be shown that the perpendicular from H to BB′ meets the side b in a point Q, such that

$$QF \cdot QD = QA \cdot QC,$$

and also that the perpendicular from H to CC′ meets the side c in a point R, such that

$$RE \cdot RD = RA \cdot RB.$$

Hence P, Q, R are three points of the radical axis of the circles O and N. The radical axis is perpendicular to their line of centers ON, the *Euler line* of the given triangle.

Solution III. *Submitted by the Editor.*

Let the vertices of the triangle be represented by the following points; A $(a, 0)$, B $(b, 0)$, C $(0, c)$; the medians are AD, BE, and CF; H the orthocenter having the coordinates $\left[0, -\frac{ab}{c}\right]$. Let P be the point of intersection of side BC with the line through H perpendicular to AD; Q the point of intersection of the side AB with the line through H perpendicular to CF; R the point of intersection of the side AC with the line through H perpendicular to BE. The coordinates of the points are

$$P\left[\frac{b(ab+c^2)}{c^2-b^2+2ab}, \frac{c(ab-b^2)}{c^2-b^2+2ab}\right],$$

$$Q\left[\frac{2ab}{a+b}, 0\right],$$

$$R\left[\frac{a\,(ab+c^2)}{c^2-a^2+2ab}, \frac{c(ab-a^2)}{c^2-a^2+2ab}\right].$$

It is not difficult to show that the following determinant vanishes, which proves that the points P, Q, and R are collinear;

$$\begin{vmatrix} \frac{b(ab+c^2)}{c^2-b^2+2ab} & \frac{c(ab-b^2)}{c^2-b^2+2ab} & 1 \\ \frac{2ab}{a+b} & 0 & 1 \\ \frac{a\,(ab+c^2)}{c^2-a^2+2ab} & \frac{c\,(ab-a^2)}{c^2-a^2+2ab} & 1 \end{vmatrix} = 0.$$

933. *Proposed by Norman Anning, Ann Arbor, Mich.*

Find integral edges for a tetrahedron all of whose sides are right triangles.

Solved by F. A. Caldwell, St. Paul, Minn.

This solution concerns only tetrahedrons represented by the figure, in which the right angles are ABC, ABD, DCA, DCB.

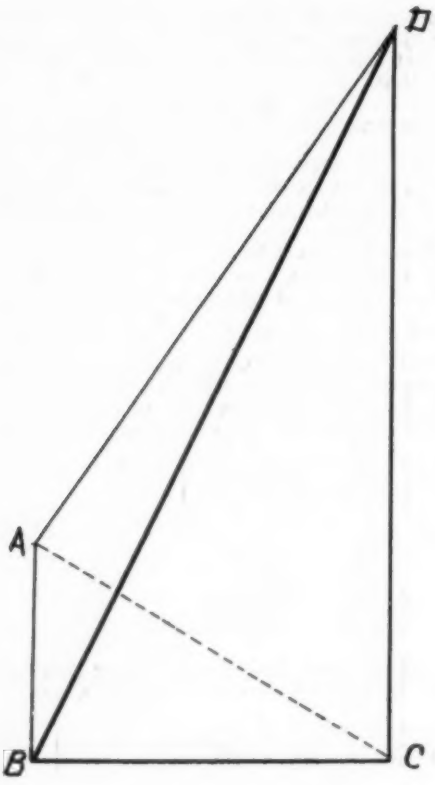
(See figure on next page.)

If two integers exist (a and b) such that ab is a perfect square, the triangle having sides $\sqrt{ab}$, $(a-b)/2$, $(a+b)/2$ will be right angled. The hypotenuse is $(a+b)/2$.

Referring to the figure, BC and BD can not be equal to each other because BD is the hypotenuse of the right triangle BCD. Hence $(AB)^2$ must have two sets of two unequal, (both even or both odd) integral factors such that (since angles DCA and DCB are right and DC is integral) the square of half the sum of one set minus the square of half the sum of the other set, is a perfect square. Again the square of half the difference of one set minus the square of half the difference of the other set, is a perfect square. Let a and b be one such set of factors and c and d another; $a>b$, $c>d$, $a>c$. Then $d>b$.

The edges of the tetrahedron will be as follows:

$AB = \sqrt{ab} = \sqrt{cd}$, $BD = (a-b)/2$, $AD = (a+b)/2$,



$BC = (c-d)/2$, $AC = (c+d)/2$,

$$DC = \sqrt{\left(\frac{a-b}{2}\right)^2 - \left(\frac{c-d}{2}\right)^2} = \sqrt{\left(\frac{a+b}{2}\right) - \left(\frac{c+d}{2}\right)^2}$$

For example, take $AB = 264$, $(AB)^2 = 69696$, $a = 2178$, $b = 32$, $c = 1056$, $d = 66$. Then $BD = 1073$, $AD = 1105$, $BC = 495$, $AC = 561$, $CD = 952$.

Again, take $AB = 153$, $(AB)^2 = 23409$, $a = 289$, $b = 81$, $c = 1377$, $d = 17$. Then $BD = 680$, $AD = 697$, $BC = 104$, $AC = 185$, $CD = 672$.

This solution is only a special case. From the standpoint of Number Theory it should be interesting to receive a general solution giving sets of integers which satisfy the conditions of the problem. *Editor.*

934. *Proposed by George Sergent, Tampico, Mexico.*

Given the feet of the perpendiculars dropped from the intersection of the diagonals of a quadrilateral to the sides; construct the quadrilateral.

Solved by the Proposer.

Analysis: Suppose the problem solved, ABCD being the required quadrilateral; E, F, G, H, the projections on the sides a, b, c, d, respectively, of the intersection, O, of the diagonals. AB and CD intersect in I, AD and BC in J.

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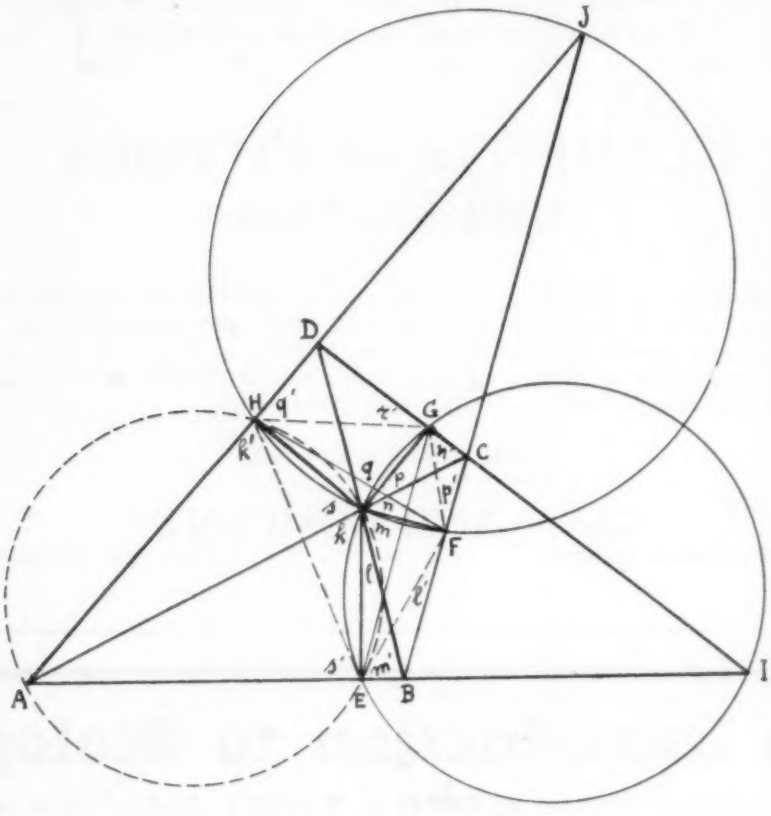

AEOH, BFOE, GGOF, DHOG are concyclic quadrilaterals. Supposing their circumcircles drawn, we see that each of two segments of a side of ABCD is a chord subtending two equal angles, one at O, and the other at the projection of O on the adjacent side.

AE subtends the equal angles AOE and AHE (k and k').

BE subtends the equal angles BOE and BFE (l and l').

BF subtends the equal angles BOF and BEF (m and m').

Let k, l, m, n, p, q, r, s, be the eight inscribed angles at O, and $k', l', m', n', p', q', r', s'$, their equal inscribed angles at E, F, G, H, respectively.

$\angle AOB = k+l = k'+l' = \angle COD = p+q = p'+q'$. (1)

In the triangle AHE, $k' = 180° - (A+s')$.

In the triangle BFE, $l' = 180° - (B+m')$.

Hence, $k'+l' = 180° - (A+B) + 180° - (s'+m') = J+E$. (2)

In the triangle CFG, $p' = \angle JCD - n'$.

In the triangle DHG, $q' = \angle JDC - r'$.

Hence, $p'+q' = \angle JCD + \angle JDC - (n'+r')$

$= 180° - J - (180° - G) = G - J$. (3)

Hence, $J+E = G-J$, from which we get $J = (\frac{1}{2})(G-E)$. (4)

In the same way, we find $I = (\frac{1}{2})(F-H)$.

We have then:

$\angle GOE = 180° - I = 180° - (\frac{1}{2})(F-H)$,

$\angle FOH = 180° - J = 180° - (\frac{1}{2})(G-E)$.

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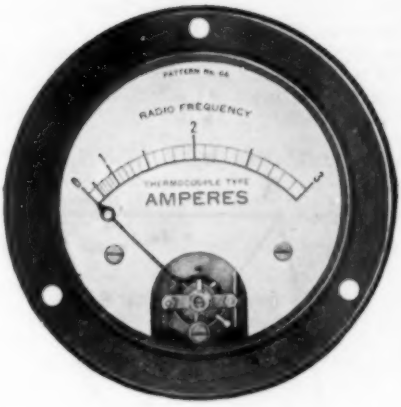

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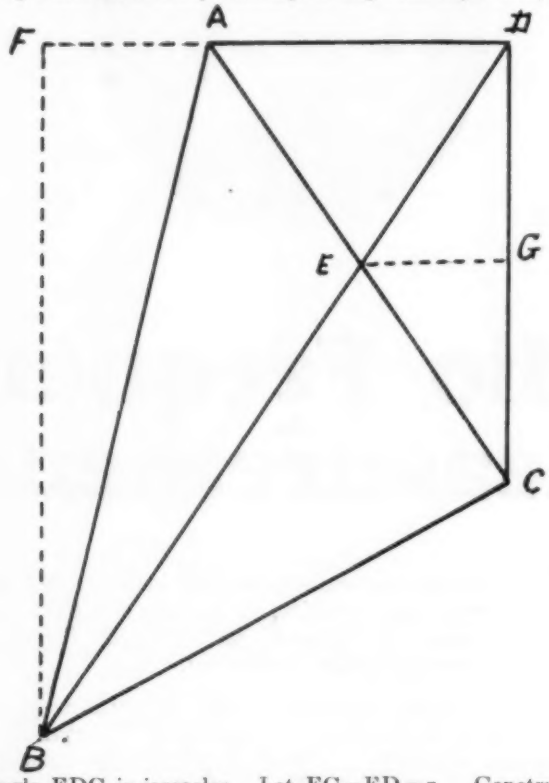
These angles are determined by the data.

Construction: On the diagonals GE and HF of the quadrilateral whose vertices are the given points, construct the arcs containing the angles GOE and FOH, respectively. Their intersection determines the point O which is the intersection of the diagonals of the required quadrilateral. The perpendiculars at E, F, G, H, to OE, OF, OG, OH, respectively determine the required quadrilateral ABCD.

935. *For High School Pupils. Proposed by Ivar Highberg, North Central High School, Spokane, Wash.*

To determine the distance between two inaccessible points A and B, two points C and D were taken, and the following measurements were made: (ABCD represents the order of the letters) DC = 850 feet; $\angle ABD = 60°$; $\angle BDC = 30°$; $\angle ACD = 30°$; $\angle ACB = 90°$. Compute AB without the use of Trigonometry.

I. *Solved by Tillie Dantowitz, Kensington High School, Phila., Pa.*



The triangle EDC is isosceles. Let $EC = ED = x$. Construct a perpendicular EG to DC. The triangle EDG is a $30° - 60°$ right triangle, and $EG = x/2$. It follows that $DE = 850\sqrt{3}/3$ feet. $\angle DBC = 30°$, and $BEC = 60°$. In triangle BCE,

$$BE = 2\,CE = 1700\sqrt{3}/3 \text{ feet.}$$

Drop perpendicular BF on DA produced. Since $\angle ADF = 60°$. $FD = BD/2 = 425\sqrt{3}$ ft. Also BF = 1275 ft. Since $\angle AED = \angle BEC = 60°$, the triangle ADE is equilateral. $AD = ED = 850\sqrt{3}/3$ ft.

$FA = FD - AD = 425\sqrt{3}/3$ ft. $AB = \sqrt{BF^2 + FA^2} = 850\sqrt{21}/3$, or 1298 tf.

Also solved by *John M. Adair, Ovid High School, Ovid, N. Y.;* and by the *Proposer.*

PROBLEMS FOR SOLUTION.

946. *Proposed by Philomathe, Montreal, Canada.*
Show how to bisect a given arc by means of a compass only.

947. *Proposed by Norman Anning, Ann Arbor, Mich.*
Show that the following expressions is independent of A:
$\cos^2(A-B)+\cos^2(A-C)-2\cos(A-B)\cos(A-C)\cos(C-B)$.

948. *Proposed by F. A. Caldwell, St. Paul, Minn.*

X is an integer which is not a prime number nor the double of a prime number. Show how to find , in terms of factors of X^2, the sides of scalene triangles (acute, right or obtuse) whose sides and areas are integral and whose altitude is X.

949. *Proposed by Daniel Kreth, Wellman, Iowa.*

Given $\sin C = 12/13$, the difference of the sides, including that angle, equal to 45, and the radius of the inscribed circle equal to 75, to construct the triangle and calculate its sides.

950. *For High School Pupils. Proposed by Nathan Altshiller-Court, Norman, Okla.*

Through two opposite vertices of a given parallelogram two lines are drawn meeting the sides of the parallelogram in four points which determine four new lines. Prove that two of these lines are parallel, and the other two meet in a point collinear with the other two vertices of the parallelogram.

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QUESTIONS AND PROBLEMS FOR SOLUTION AND DISCUSSION.

Comparison of Examinations Questions—Progress or Not?

482. How much difference exists between the teaching of Botany today and twenty years ago?

a. Subject matter;
b. Laboratory work;
c. Method of conducting classes;
d. Demonstrations;
e. Examinations and examination questions;
f. Applicability to daily life;
g. Distinct improvements;
h. Retrogressions—If worse, specify exactly how and where.

The above questions offer opportunity for the readers of this department and for all who are deeply interested in the improvement of science teaching in general to express either their satisfaction or dissatisfaction with present conditions.

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A comparison of the papers that follow will give some food for thought.

Answer the questions asked above.

TWENTY YEARS LATER

BOTANY—1926

Friday, June 25, 1926, 9 a. m. Two hours.

Answer three questions of each group and one additional question which may be selected from any group. Candidates are advised to apportion the time wisely among the ten questions answered. Number each answer to correspond with the question selected.

GROUP I

1. Name three features that may appear in leaves of plants growing in arid regions. Explain the advantage of each one. Name two plants illustrating each feature.
2. Define *ten* of the following terms: prothallium, petiole, cellulose, zoospore, calyptra, nectar, hybrid, perianth, monoecious, chromosome, respiration, rhizoid, gamete.
3. What are the characters by which you would distinguish the cross-section of a young root from that of a stem? Name three modifications of the root and state the benefit to the plant of each.
4. Explain the structure of a winter bud. State the functions of each of its parts. What happens when it opens? How does it differ from an embryo?
5. Write down the letters *a* through *j* in your answer book and after them place the word or phrase selected from among those in italics which most accurately completes the following statements:
   a) The structure from which the seed develops is called a *seedling, embryo, ovule, egg-cell.*
   b) The region of elongation in a root is the *root-tip, meristem, root cap, central cylinder.*
   c) Excurrent trees owe their shape to the vigor of the *terminal bud, long internodes, crowding by other trees, heliotropism.*

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d) The chromosome number in the sporophyte is *half, double, the same as that of the gametophyte.*

e) The potato tuber is a *thickened root, bud, rootstock, seed, stem.*

f) The stamen corresponds morphologically to the following organ of the lower plants: *antheridium, ascus, sporophyll, sporangium, sperm cell.*

g) A fruit which remains closed after maturity is called *fleshy, dry, aggregate, a pome, indehiscent, accessory.*

h) Transpiration is most useful to the plant because it *cools the plant, gets rid of injurious water, allows fresh water to enter the plant, gets rid of other wastes.*

i) A species whose members show individual flowers possessing stamens and pistils of two markedly different heights is called *dichogamous, dimorphic, dioecious, dicotyledonous.*

j) The structure around which starch is deposited in algae is called the *centrosome, pyrenoid, vacuole, chloroplast.*

GROUP II

6. Concerning secretion in plants name
   a) three specialized regions from which secretion may occur,
   b) the kind of material secreted in each case,
   c) the role of these secretions in the plant.
7. In one word give the name for:
   a) the growing of the stem towards the light
   b) agents that bring about digestive changes in foods
   c) the contraction of cell contents due to the withdrawal of water by osmosis
   d) the food material outside the embryo of a seed
   e) the leaf-bearing region of a stem
   f) the transfer of water from the root to the stem of a woody plant
   g) rigidity of a cell due to a high water content
   h) the ovule-bearing tissue of the pistil.
8. Answer *four* of the following:
   a) Is light necessary for germination? Why, or why not?
   b) Tell with reasons whether you think annual or perennial species would suffer more by a failure of the flower to set seeds.
   c) Tell why seeds of (tomatoes, for instance) may often be started in a much poorer soil than the kind the plant needs at a later date.
   d) Why are oxygen and moisture necessary for germination?
   e) Why does the tap root of the seedling grow down into the soil while the lateral roots grow out from the tap root at various angles?
9. Copy the following sentences, omitting any words which make the statements incorrect:
   a) The function of bud scales is to protect them from cold, light, evaporation.
   b) Potatoes, carrots, onions, are storage roots.
   c) Decay is caused by air, algae, bacteria.
   d) Light is essential for the manufacture of sugar, proteins, fat.
   e) Photosynthesis is carried on by Rhizopus, yeast, fern prothallia.
   f) The tip of the root is protected by root hairs, epidermis, cap.
   g) The osmotic membrane in the plant cell is the cell wall, protoplasm, cutin.
   h) The prothallium, stem, leaf, belong to the sporophyte generation of the fern.
   i) The process of mitrosis results in an equal division of the cell sap, cytoplasm, nucleus.
   j) A grain of corn, a cabbage, a pea, is a fruit.
10. Tell with reasons whether the following statements are true or false:
   a) All responses to stimuli in higher plants are due to unequal growth.
   b) Root hairs develop more abundantly in moist soil than in dry.
   c) Alternation of generation is found only in the mosses and ferns.
   d) The corn grain shows hypogeal germination.
   e) The plant cell consists entirely of protoplasm of one kind or another.

GROUP III

11. What structural or physiological characteristics must a plant have to make it (*a*) a good source of fiber, (*b*) good material for fence-posts, (*c*) a source of rubber, (*d*) a good root crop, (*e*) a good fertilizer?
12. With the understanding that immunity to rust is a recessive quality and susceptibility a dominant quality in wheat, answer the following:
   a) If from the cross of a susceptible and an immune variety there are

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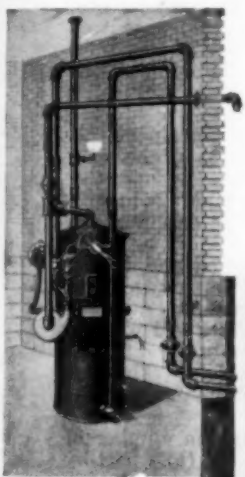

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480 individuals produced, tell how many will be immune and how many susceptible.

b) If we inbreed the individuals produced in (*a*) and obtain 480 seeds, tell how many will produce immune and how many susceptible plants.

c) If we inbreed the offspring of an early-ripening susceptible wheat and a late-ripening immune wheat and get 480 new plants (understanding that late-ripening immune is the dominant characteristic) give the numbers and description of four different types that will be formed.

13. *a*) Describe two types of scale leaves one of which is useful to the plant and to man. State the use of each type to the plant. Give examples.

b) What is cork? Describe its structure and formation.

14. What are the methods of combating *five* of the following diseases: wheat rust, damping off fungi, downy mildew of grape, potato wart, pine blister rust, potato blight, black knot, apple rust, chestnut blight?

15. Name three commercially important derivatives from the bark of plants; three substances contained in leaves which may make them valuable as food; three useful seed products; one substance other than food derived from fruits.

---

483. Contributed by C. W. Weaver, Grafton, W. Va.
Recently used in the Grafton High School.

a. What comments on the relative excellence of this style of examination?

b. Just what does it find out?

c. Does it show how much the pupil knows?

CHEMISTRY EXAMINATION.

In each of the statements there are several choices for the last word or groups of words. One or more than one will make the statement correct. Under-line all of these that make correct statements.

1. Oxygen is found (1) in water, (2) in the air, (3) in pure metals, (4) in the earth's crust, (5) in all plants and animals.

2. Oxygen may be prepared, (1) by heating metals in air, (2) by electrolysis of water, (3) by heating Potassium Chlorate with manganese dioxide, (4) by heating mercury oxide (5) by the reaction of certain metals on water, (6) by the evaporation of liquid air.

3. The following are properties of oxygen, (1) heavier than air, (2) very soluble in water, (3) unites rapidly with most elements at a low temperature, (4) does not unite with other elements at a high temperature.

4. Pure oxygen is used, (1) in the treatment of typhoid, (2) by aviators at high altitudes, (3) in fire extinguishers, (4) by rescue parties in mines.

5. In the human body oxygen, (1) purifies the blood, (2) builds up the tissue, (3) aids the circulation, (4) slowly oxidizes the tissue furnishing heat to the body.

6. Hydrogen may be prepared (1) by the reaction of certain metals on water, (2) by the reaction of certain metals on oxygen, (3) by the reaction of certain salts on acids, (4) by the electrolysis of water.

7. Pure Hydrogen gas is used (1) in balloons and airships, (2) in submarines, (3) to convert certain oils to hard fats, (4) in the oxyhydrogen torch.

8. By volume water is composed of (1) 2 parts oxygen and 1 part hydrogen, (2) 8 parts oxygen and 1 part hydrogen, (3) 1 part oxygen and 2 parts hydrogen, (4) 2 parts hydrogen and 1 part nitrogen.

9. Samples of a pure substance from any place in the world will (1) sometimes contain (2) always contain, the (1) same elements, (2) different elements, in (1) different, (2) the same proportions of weight. This is a statement of the law of (1) conservation of matter, (2) definite proportions, (3) solubility, (4) multiple proportions.

10. By the Reacting weight of an element we mean the number of parts by weight of the element that combine with or replace (1) 1 part by

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weight of Hydrogen, (2) 8 parts by weight of Hydrogen, (3) 1 part by weight of oxygen.

11. In a true solution particles of the dissolved substance, (1) can be seen, (2) do not settle out, (3) are uniformly distributed in the solvent, (4) cannot be seen.

12. A dilute solution is one containing, (1) a large amount of the dissolved substance, (2) as much of the dissolved substance as it can hold, (3) a small amount of the dissolved substance.

13. A crystaline substance that loses its water of crystalization on exposure to air is (1) deliquescent, (2) effervescent, (3) hygroscopic, (4) efflorescent.

ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany, October, *Brooklyn Botanic Garden, Lancaster, Pa., $6.00 a year, 75 cents a copy.* A Study of Suction Force by the Simplified Method II. Periodic Variations and the Influence of Habitat, Francis John Molz. Facultative Parasitism and Host Ranges of Fungi, Paul A. Young.

American Mathematical Monthly, August-September, *Menasha, Wis., $5.00 a year, 60 cents a copy.* On the Asymptotic Expressions for Jacobi and Legendre Polynomials Derived from Finite-Difference Equations, J. A. Shohat, University of Chicago. Some Applications of Mathematics Equations to Architecture; Gothic Tracery Curves, E. C. Phillips, Georgetown University. On the De Longchamps Circle of the Triangle, Nathan Altshiller-Court, University of Oklahoma.

Education, October, *The Palmer Co., Boston, $4.00 a year, 40 cents a copy.* Some of the Conditions for Racial Progress, R. Howard Claudius. Philadelphia, Pa. The Essentials of the Socialized Recitation, C. L. Robbins, State University of Iowa. The Socialized Recitation in General Science, Anna Chandler Williams, Kalamazoo, Michigan. The Apprentice and His Tools, Monroe W. Sloyer, Lancaster, Pa. The Education of the Gifted Child, Prof. K. A. Sarafian, La Verne College, La Verne, Calif. A Substitute for the School Weekly, John Albrecht Thalheimer, Phoenix Union High School, Phoenix, Arizona. Financial Management of School Organizations, A. E. Holch, Nebraska State Teachers' College, Peru, Nebraska.

Journal of Chemical Education, October, *Rochester, N. Y., $2.00 a year, 35 cents a copy.* Four Eminent Chemists Who Died Before Their Time, E. Raymond Riegel, University of Buffalo, Buffalo, N. Y. The Structure of Matter: I. The Atom, Maurice L. Huggins, Standford University, California. Chemistry of the Citrus Industry in California, Eloise Jameson, Corona, California. A Deviation from the Stereotyped Method of Teaching Freshman Chemistry, W. A. Felsing, University of Texas. The Dye Industry in America, R. Norris Shreve, Consulting Chemist, New York City. Cooperation between the Eastern New York Section of the A. C. S. and the High Schools, Wheeler P. Davey and Thomas A. Wilson, General Electric Company, Schenectady, New York. The Selective Value of Powers' General Chemical Test, Scale "A", Lawrence Edward Stout, Miami University, Oxford, Ohio. Inorganic Chemistry for Home Economics Classes, Nellie M. Naylor, Iowa State College. Water as the Basis for a Study of Chemistry, Mary Louise Foster, Smith College, Northampton, Mass.

Journal of Geography, October, *2249 Calumet Avenue, Chicago, $2.50 a year, 35 cents a copy.* The Cork Oak, W. O. Blanchard, University of Illinois. Geography in the Junior High School, Maude Cottingham Martin, Junior High School, Cleveland Heights, Ohio. Commerce and Industry: Its Place and Function in a Commercial Course, Jessie B. Strate, Withrow High School, Cincinnati, Ohio. Suggestions to Rural School Teachers of Geography, Vincent Gatto, Raymond, New Hampshire. Geography's Affiliations, G. T. Renner Jr., Columbia University. A Rejoinder to "Geography's Affiliations," O. D. von Engeln, Cornell University.

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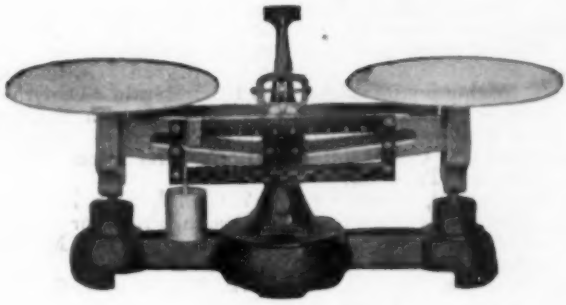

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National Geographic Magazine, October, *Washington, D. C., $3.50 a year, 50 cents a copy.* Canada from the Air, J. A. Wilson, Secretary, Royal Canadian Air Force. Carnival Days on the Riviera, Maynard Owen Williams. Hunting an Observatory, C. G. Abbot, Assistant Secretary, Smithsonian Institution.

Photo-Era, August, *Wolfeboro, N. Hampshire, $2.50 a year, 25 cents a copy.* The Pictorialist's Own Season, Arthur H. Farrow. Alone With a Camera, Arthur L. Marble. Photographing the Yellowstone, Part II, Lloyd W. Dunning. Picturesque New Orleans, C. B. Neblette.

Popular Astronomy, October, *Northfield, Minn., $4.00 a year, 45 cents a copy.* Changes in Jupiter's Belts, Latimer J. Wilson. Report on Mars, No. 37, William H. Pickering. The Proper Motion of the Andromeda Nebula, Oliver J. Lee. An International Co-operation for the Photographic Study of Cepheids, Francois C. Henroteau. An Apartment House Observatory, William Braid White. Astrology, Joseph M. Synnerdahl. Time Measured Graphically, Frederic R. Honey.

Popular Science Monthly, November, *250 Fourth Avenue, New York, $2.50 a year, 25 cents a copy.* Bootleg Oil, Myron M. Stearns. Thrills I Never Had, Fitzhugh Green. Latest Planes Herald New Era of Safety, Edgar C. Wheeler. The Fastest Living Thing, Edwin Ketchum. Will 1927 be a Year Without a Summer, Paul A. Williams. Huge Structures Built Noiselessly, H. C. Davis. America's First Great Experimenter, Archibald Douglas Turnbull.

Science, October 22, *Grand Central Terminal, New York City, $6.00 a year, 15 cents a copy.* Function and Design, Professor J. B. Leathers. The Relation of Evolution to Medicine, Dr. Dudley J. Morton. Field Trips in Geology, Professor Douglas Johnson.

Scientific American, October, *New York, $4.00 a year, 35 cents a copy.* Cold Lights of the Sea, David Starr Jordan, Leland Stanford Jr. University. Redetermining the Velocity of Light, Henry Norris Russell, Ph. D. The Salvage of the "S-51", Edward Ellsberg, U. S. N. Amateurs Find Marconi was Right, Orrin E. Dunlap Jr. Hunting Fossil Insects, T. D. A. Cockerell, University of Colorado. Little-known Ice Ages of Great Antiquity, Albert G. Ingalls. The Scourge of the Japanese Beetle, J. L. Miller. Yale's Great New Museum of Evolution, Richard Swann Lull, Yale University.

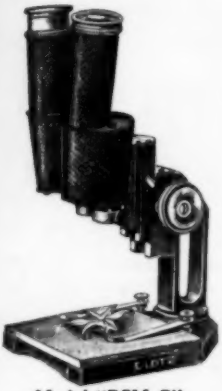
Scientific Monthly, October, *The Science Press, New York, $5.00 a year, 50 cents a copy.* Cuicuilco and the Archaic Culture of Mexico, Byron Cummings, Tucson, Arizona. Race and Culture, Professor Wilson D. Wallis, University of Minnesota. The Trend of Public Health Work: Is It Eugenic or Dysgenic? Professor Mazyck P. Ravenel, University of Missouri. How Fossils Got into the Rocks, Dr. Wendell P. Woodring, U. S. Geological Survey. Are the Heavens Full or Are They Void? A History of Hypotheses, Professor Florian Cajori, University of California.

The School Review, October, *University of Chicago Press, $2.50 a year, 30 cents a copy.* Magazines which High-School Pupils Read, Henry O. Severance, University of Missouri. A Method of Teaching Chemistry, Mary Isabel Henkel, West Division High School, Milwaukee, Wisconsin. The Provision of Moral Education for Pupils in the Senior High School, Sarah Elizabeth Bundy, Jefferson High School, Los Angeles, California. A Suggested Technique for Selecting High-School Pupils Who May be Allowed to Plan Their Own Lesson Assignments, A. W. Hurd, North High School, Minneapolis, Minnesota.

BOOKS RECEIVED.

An Introduction to Biology, by Alfred C. Kinsey, Sc. D., Associate Professor of Zoology, and Waterman Research Associate Indiana University. Cloth. Pages xiv+558. 13x19½ cm. 430 illustrations. 1926. J. B. Lippincott Company.

General Botany, by C. Stuart Gager, Ph.D., Sc. D., Ph. D. Director of the Brooklyn Botanic Garden and Orland E. White, Sc. D. Curator of Plant Breeding and Economic Plants, Brooklyn Botanic Garden. Cloth. Pages xiv+1056, 14x21 cm. 689 illustrations. 1926. P. Blackiston's Son and Co. Price $4.00.



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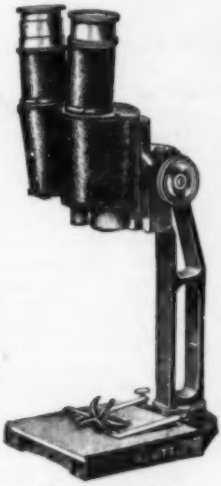

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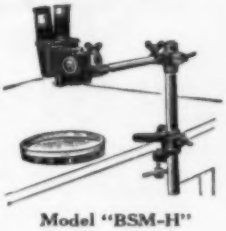

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New Complete School Algebra, by Herbert E. Hawkes, Ph. D. Professor of Mathematics in Columbia University, William A. Luby, A. M. Head of Department of Mathematics in Junior College of Kansas City, Frank C. Touton, Ph. D. Professor of Education in the University of Southern California. Cloth. Pages vii+625. 12x18 cm. 1926. Ginn and Co. Price $1.60.

Junior High School Mathematics, Book III, Revised Edition, by George Wentworth, David Eugene Smith and Joseph Clifton Brown. Cloth. Pages iv+338. 12x19 cm. 1926. Ginn and Co. Price $1.20.

The Comprehensive High School, by Milo H. Stuart, Principal of the Arsenal Technical Schools Indianapolis. Cloth. viii+127. 12x18 cm. 1926. The Macmillan Co.

Freshman Hygiene, by Raymond C. Bull, A.B., M.D. Director of Student Health Service, Lehigh University and Stanley Thomas, M.S., M.A. Associate Professor of Bacteriology, Lehigh University. Cloth. Pages x+288. 13x20½ cm. 74 illustrations. 1926. J. B. Lippincott Co. Price $2.00.

Elements of Economics, by Charles Ralph Fay, M. A., Erasmus Hall High School, Brooklyn, N. Y. Cloth. Pages vii+631. 13x20 cm. 1926. The Macmillan Co.

The Dial Machine, An Apparatus for the Elementary Mathematical Laboratory, by T. C. J. Elliott, Paper. 98 pages. 12x18 cm. 1926. The Peterborough Press, Ltd., Cross Street, Peterborough. Price 4/6.

Laboratory Manual of High School Geography, by E. E. Ramsey, A.M., Professor of Education, State Normal School, Terre Haute, Indiana, and J. A. Price, formerly head of the Department of Physiography, Fort Wayne High School, Fort Wayne, Indiana. Paper. Pages iii+202. 20½x27 cm. 1926. The Macmillan Co.

Arithmetic Work-Book, Grade 7, by F. B. Knight, G. M. Ruch and J. W. Studebaker. Paper. Pages iii+74. 20x28 cm. 1926. Scott, Foresman and Company. Price: Pupils' Edition 36 cents, Teachers' Edition 48 cents.

The M. O. S. Book, by C. H. Ward, Paper. 215 pages. 17×24 cm. 1926. Scott, Foresman and Co. Price 60 cents.

PAMPHLETS RECEIVED.

Eye Sight Conservation Bulletin No. 5, published by the Eye Sight Conservation Council of America, Times Building, New York City. Paper. 95 pages. Price 40 cents. Contains lecture material and a catalog of lantern slides for use of speakers wishing to assist in the eye sight conservation movement.

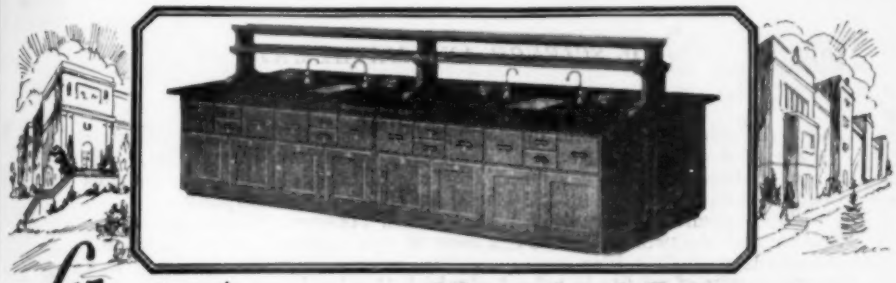
Objective Tests for High School Physics, by C. J. Peters and R. K. Watkins, University of Missouri, Columbia, Mo. A 36-page pamphlet of tests which will be mailed free to physics teachers who will cooperate in standardization.

Pupils' Outlines for Home Study in Connection with School Work, North America and South America, by George J. Miller, State Teachers College, Mankato, Minn. Paper. 31 pages. Single copies 20 cents with discount for ten or more copies.

An Outline for Dictionary Study based on Webster's Collegiate Dictionary. G. & C. Merriam Company, Springfield, Mass. This 12-page pamphlet is a valuable aid in teaching how to use a dictionary in studying, spelling, pronunciation, derivation, definition, usage, etc. It should be in the hands of every student who has not mastered the use of the dictionary.

Diphtheria—Curable and Preventable, 12 pages, and Smallpox—A Preventable Disease, 20 pages, are two bulletins published by the American Association for Medical Progress, Inc., 370 Seventh Avenue, New York City.

Youth and the Beautiful, by Henry C. Frick Educational Commission, 439 Union Trust Bldg., Pittsburgh, Pa. Paper. 80 pages. "The report of a recent experiment in introducing a group of outstanding artists direct to high school pupils."



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BOOK REVIEWS.

Pupil Adjustment in Junior and Senior High Schools, by William Claude Reavis, Assistant Professor of Secondary Education and Principal of the University High School, University of Chicago. Cloth. Pages xviii+348. 12x19 cm. 1926. D. C. Heath and Company.

"The student in difficulty . . . . . has become a challenge to the teacher and the principal. He has become a prospect of unknown value." Recognition of this idea prompted Dr. Reavis to make the long and careful study of misfits in school of which this book is a report.

The book is composed of three parts. Part I gives a clear statement of the problems of maladjustment; shows how the case method has been developed in medicine, social work and related fields; and explains the technical application of a similar method of procedure in the field of education. Part II is the history of a number of the cases studied—not theoretical pupils whom the author could make act to fit a theory, but pupils of the University High School. They are all typical cases including deficient previous school training, physical disability, endocrine deficiency, speech disability, and other cases all common in any school but frequently ignored or not recognized. The study of each case gives in detail (1) the diagnostic procedure, (2) the remedial treatment prescribed, and (3) the effect of this treatment. The third part of the book consists of three appendixes giving (A) Selected references on pedagogical case accounts, (B) Selected references on medical diagnosis, and (C) Forms used in recording personnel data on pupils enrolled in the University High School.

This book is a pioneer in its field. It will be a great help to school administrators, supervisors, and teachers. Social workers will find it interesting and valuable. The author does not claim to have found a cure for all educational ills due to maladjustment but he has shown some definite things that can be done for the fifteen or twenty per cent of failing pupils in nearly every high school which will result in permanent advantage to them. In reading the book one becomes conscious of the serious error of many schools or entire educational systems that make no provision for scientific diagnosis and treatment of individual cases but seem content with giving all pupils the same treatment and expecting 100% success in results. G. W. W.

A Second Course in Algebra, by J. C. Stone, Head of the Department of Mathematics, State Normal School, Montclair, New Jersey, and H. F. Hart, Head of the Department of Mathematics, Junior and Senior High Schools, Montclair, New Jersey. pp. 294. 13x19 cm. 1926. Chicago. Benj. H. Sanborn and Company.

The authors have attempted to arrange topics in such a way that a foundation is laid for each subsequent skill and further that each skill is kept constantly in play.

Considerable attention has been given to the notion of functionality. The technique of problem solving is developed. There is a chapter on applied trigonometry and there are topics of an advanced character which will appeal to the bright pupil. J. M. Kinney.

Junior Mathematics, Book III, by Ernst R. Breslich, Assistant Professor of the Teaching of Mathematics, the College of Education, and Head of the Department of Mathematics, the University High School of the University of Chicago. pp. 254. 13.5x19 cm. 1926. New York. Macmillan.

One who is not acquainted with the first two books of Prof. Breslich's Junior series would be surprised to find in this third book material which is usually found in the so-called advanced algebra of the senior high school. In fact a pupil who has completed the work outlined in the three books of this Junior High School series will not only have mastered the requirements of the Senior High School but will also have acquired a large amount of intuitive geometry.

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Arithmetic Work-Books, Grade Three, By F. B. Knight, G. M. Ruch, and J. W. Studebaker. pp. 80. Pupils' Edition, $.36, Teachers' Edition, $.48. Chicago: Scott, Foresman and Company.

The authors announce that with the publication of this book, the Work-Book series is complete for all grades from the third to the sixth inclusive.

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These books are written in an attractive style. There are many illustrations and drawings. It seems to the reviewer that children furnished with these attractive books would take great delight in "doing" arithmetic. J. M. Kinney.

The New Mathematics, Books One and Two, by John C. Stone, State Normal School, Montclair, New Jersey. 1926. Chicago: Benj. H. Sanborn and Company.

These books are designed for the first and second year of the Junior High School. The author believes that a pupil entering the Junior High has a right to expect a new kind of mathematics in place of a review and continuation of the work of sixth year. Accordingly he introduces material at the outset which is new to the pupil.

The first chapter opens with the project of laying out a tennis court. Frank and Charles in measuring with a foot rule discover they do not get the same measurements that they obtain with a yard stick. Thus they are led to discuss sources of error and finding amounts of error. Then comes the problem of laying out square corners, and finally the construction of a plan of the court.

As a second project Dorothy and Helen mount some pictures. This introduces the use of compasses and the T-square.

These illustrations indicate the character and treatment of the subject matter. The pupil works with interesting material. He finds that mathematics is a useful subject.

During the two years' work the author aims to give the pupil as much of the practical uses of mathematics as he is able to comprehend; to give him sound mathematical training in thinking in terms of quantitative relationships; to give him some appreciation of the part played by mathematics in our present civilization; and to help him see the beauty of geometrical design in nature, art, and industry. J. M. Kinney.

A Survey Course in Mathematics, by N. J. Lennes, Professor of Mathematics, University of Montana, with the Editorial Cooperation of H. E. Slaught, Professor of Mathematics in the University of Chicago. pp. 212. 14.5x21 cm. $2.00. 1926. New York: Harpers.

In recent years there has arisen a feeling on the part of a great number of people that an attempt should be made to present to the student of the junior college entering upon a course in any field a survey of the course which would orient him not only with respect to the particular subject but with respect to other subjects. Thus a course in mathematics should be offered to a freshman which will give him an idea as to what more advanced mathematics has to offer, and how the sciences, numerous occupations, in fact, our present material civilization depend vitally upon it.

It is from this point of view that Professor Lennes has written this survey course in Mathematics.

There are four chapters as follows: I. Trigonometry; II. Functions and Their Graphic Representation; III. Derivatives and Their Uses; IV. The Integral and its Uses.

The book is written in a style which should hold the interest of any student. J. M. Kinney.

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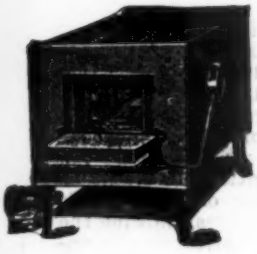

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The Work of the College Entrance Examination Board, 1901-1925. Cloth. Pages ix+300. 15x23 cm. 1926. Price $4.00. Ginn and Company.

Here is a book which deserves the attention of teachers, supervisors and administrators in all departments of our educational system. To many the title is uninviting. They should first read the subtitle: "The Solution of Educational Problems Through the Cooperation of All Vitally Concerned." Those who regard written examinations an evil should read a few extracts from this extraordinary volume. On page 163 the secretary for the year 1919 sums up the values of written examinations to students. Page 202 discusses the trustworthiness of the Board's examinations; page 53, the validity of the Board's measures, showing the correlation between the rating obtained by means of the entrance examinations and the academic standing of students.

All will be interested in the first forty-three pages containing an article by Nicholas Murry Butler on "How the College Entrance Examination Board Came to Be," "A Brief History of the College Entrance Examination Board" and "The College Entrance Examination Board a Retrospect and Prophecy" by Wilson Farrand, "The Art of Examination" by A. Lawrence Lowell. "Has the College Entrance Examination Board Justified Its Quarter Century of Life" by Henry S. Pritchett, and "The College Entrance Examination Board Pioneer in the Solution of Educational Problems by the Cooperation of Those Concerned" by Julius Sachs.

The next twenty pages are concerned with the "scholastic aptitude test" or that type of tests known as "intelligence tests," "mental ability tests," etc. This is followed by a large section of the book giving digests of the publications of the Board.

When one notes the phenomenal growth of the work of the Board, starting with less than 1000 candidates in 1901 and examining nearly 20,000 in 1925, he is impressed with the influence it exerts over both secondary schools and colleges; but this influence does not end even here for the investigations and reports of its committees are followed and studied by educators everywhere. G. W. W.

Mathematical and Physical Papers 1903-1913, by Benjamin Osgood Peirce, Late Hollis Professor of Mathematics and Natural Philosophy in Harvard University. Cloth. Pages viii+444. 15x23½ cm. 215 illustrations. 1926. Harvard University Press. Price $5.00.

This is a truly wonderful series of papers by a great thinker. Professor Peirce was one of that small group of investigators who did not get too great nor too busy to write out the results of his studies in clear, concise language. It is indeed fortunate that these papers have been collected from the various volumes of Proceedings in which they were originally published, and are now offered to students of science in a single volume, which is itself a work of art. The author has supplemented his descriptions of methods employed, of apparatus used, and of the results obtained by many photographs, drawings and graphs. He has recorded complete tables of data and results, and has developed the mathematical theory involved.

The book consists of twenty-one papers. Of these, four are strictly mathematical in character; one deals with the damping of oscillations by air resistance; one discusses the theory of long period, ballistic galvanometers; and one is a study of the "effect of leakage at the edges upon the temperatures within a homogeneous lamina through which heat is being conducted." All the others are studies relating to magnetism and electromagnetism. These thirteen papers giving careful description of the materials studied and the methods used, illustrated by graphs showing the magnetic properties of various kinds of iron and steel and curves of permeability, reluctivity, hysteresis, and current characteristics, constitute a valuable collection for the student of magnetism. Even the student who has little mathematical ability will enjoy such papers as No. X, "On the Magnetic Behavior of Hardened Cast Iron, and of Certain Tool Steels at High Excitations," and several others in the list.

This splendid volume should serve as a model for future collections of the reports of the investigations of our great scientists. G. W. W.